NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

ACQUISITION STRATEGIES FOR AGING AIRCRAFT: MODERNIZING THE MARINE CORPS' CH-53E SUPER STALLION HELICOPTER

by

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December 2001

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Report Documentation Page

Report Date	Report Type	Dates Covered (from... to)
19 Dec 2001	N/A	-

Title and Subtitle Acquisition Strategies for Aging Aircraft: Modernizing the Marine Corps' CH-53E Super Stallion Helicopter	**Contract Number**
	Grant Number
	Program Element Number
Author(s) Fowler, Matthew J.	**Project Number**
	Task Number
	Work Unit Number
Performing Organization Name(s) and Address(es) Naval Postgraduate School Monterey, California	**Performing Organization Report Number**
Sponsoring/Monitoring Agency Name(s) and Address(es)	**Sponsor/Monitor's Acronym(s)**
	Sponsor/Monitor's Report Number(s)
Distribution/Availability Statement Approved for public release, distribution unlimited	
Supplementary Notes	
Abstract	
Subject Terms	
Report Classification unclassified	**Classification of this page** unclassified
Classification of Abstract unclassified	**Limitation of Abstract** UU
Number of Pages 158	

REPORT DOCUMENTATION PAGE			*Form Approved OMB No. 0704-0188*

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington DC 20503.

1. AGENCY USE ONLY ***(Leave blank)***	**2. REPORT DATE** December 2001	**3. REPORT TYPE AND DATES COVERED** Master's Thesis

4. TITLE AND SUBTITLE: Acquisition Strategies for Aging Aircraft: Modernizing the Marine Corps' CH-53E Super Stallion Helicopter	**5. FUNDING NUMBERS**
6. AUTHOR(S) Fowler, Matthew J.	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000	**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A	**10. SPONSORING / MONITORING AGENCY REPORT NUMBER**

11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.	**12b. DISTRIBUTION CODE**

13. ABSTRACT *(maximum 200 words)*

This thesis explores various acquisition and contracting issues relevant to the proposed United States Marine Corps' CH-53E Super Stallion helicopter modernization. The research includes a preliminary cost and operational effectiveness analysis that identifies critical requirements issues and potential acquisition and contracting pitfalls. Cost and effectiveness modeling draws on multi-attribute decision analysis and simulation software to capture the complexities and uncertainties inherent in this modernization program. Based upon this analysis, literature research and interviews with acquisition managers and industry professionals, pertinent issues for developing an acquisition strategy are analyzed and discussed.

Some acquisition strategy issues analyzed include risk management, cultural and institutional obstacles to success, competition, integrated contract management, opportunities for tailoring and streamlining, opportunities for exploiting the most recent revision of the Department of Defense 5000 Series, contractor logistic support, operating and support cost reduction and control and finally, political considerations. Various incentive arrangement structures are suggested to ensure programmatic success. Lessons and methodologies that can be extrapolated from this case study to other aging aircraft modernization programs are identified to aid in developing other acquisition strategies.

14. SUBJECT TERMS Acquisition Strategy, Modernization, Major Weapons Systems, Helicopter, Cost Effectiveness Analysis, Aging Aircraft	**15. NUMBER OF PAGES** 158
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	**18. SECURITY CLASSIFICATION OF THIS PAGE**	**19. SECURITY CLASSIFICATION OF ABSTRACT**	**20. LIMITATION OF ABSTRACT**
Unclassified	Unclassified	Unclassified	UL

NSN 7540-01-280-5500 Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18

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ACQUISITION STRATEGIES FOR AGING AIRCRAFT: MODERNIZING THE MARINE CORPS' CH-53E SUPER STALLION HELICOPTER

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Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
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ACKNOWLEDGMENTS

The author would like to acknowledge the financial support of RADM Donald R. Eaton (USN/Ret.) of the Naval Postgraduate School and Colonel Kevin Janowsky of the H-53 & Executive Transport Helicopters Program Office (PMA-261), for sponsoring travel to the Naval Air Systems Command and the 2001 Aging Aircraft Symposium. The research benefits and insight provided by these trips was truly invaluable in the writing of this thesis.

The author would like to thank his advisors: Colonel David F. Matthews (USA/Ret.), RADM Donald R. Eaton (USN/Ret.) and Dr. William Gates for their patience and guidance in working on this document. Additionally, the author would like to extend is sincerest thanks to all the personnel at the PMA-261 and the Naval Air Systems Command who gave of their time and energy in developing this work. In particular the author would like to acknowledge Colonel Paul Croisetiere, Mr. Paul Bogner and Major James Harp for their time and expert guidance without which this document could not have been completed.

Lastly, but certainly not least, the author wishes to acknowledge his wife, Jackie, who provided her unconditional support and encouragement throughout the entire graduate education process. Without her support and understanding this project could never have been completed.

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I. INTRODUCTION

A. PREFACE

As the fleet of American combat aircraft age, the Department of Defense (DoD) is faced with an ever-expanding problem: how to keep aging aircraft technologically relevant and capable given tightening fiscal constraints. Balancing requirements for greater capabilities without major procurement funding has become increasingly problematic as aviation systems age. A complete and thorough understanding of requirements and their associated costs and benefits is integral in developing innovative business approaches to purchase, field, and support systems for tomorrow's warfighters. This research studies and analyzes those linkages.

The recent renovation of the Defense Acquisition System, promulgated in the 2001 rewrite of the DoD 5000 Series, provides a unique opportunity for innovative business approaches. Acquisition managers now have greater flexibility to tailor procurements; inserting new programs at various stages in the acquisition process can dramatically shorten the amount of time required to field new or updated systems. The ability to insert new technologies into our current weapon systems is perhaps the greatest force multiplier.

The challenge now facing acquisition managers of the Marine Corps' CH-53E Super Stallion helicopter is like that of many other aviation systems. While the CH-53E is a relatively new helicopter, current utilization rates will cause significant numbers of aircraft to reach their service life limits beginning in 2011 [Ref. 1]. Currently, the Marine Corps Aviation Implementation Plan (AIP) calls for the CH-53E to remain in service until approximately 2025 [Ref. 2], when it will likely be replaced by the Joint Common Lift (JCL). Recent studies indicate that the critical role the CH-53E would play in a major operation or war cannot be adequately compensated for by the substitution of other platforms [Ref. 3]. Thus, the gap in capabilities must be bridged in order to ensure the Marine Corps can effectively carry out its future missions.

Developing an acquisition strategy to provide that bridge to the fleet is the issue of this research. In order develop such an acquisition strategy, and subsequent contracting plan; managers must have a thorough understanding of the requirements they seek to meet. A firm grasp on requirements allows decision-makers to make better business decisions in matching risks with resources and thus providing the greatest benefit to the final system user. Conducting a cost-effectiveness analysis provides just such an in-depth knowledge of the marginal costs and benefits of meeting those requirements. Armed with this knowledge, the acquisition manager can better appraise options and cost vs. performance tradeoffs, as well as recognize potential pitfalls earlier in the acquisition process.

The current proposal to ensure the CH-53E meets the Marine Corps' requirements involves a six-point modernization plan that includes a Service Life Extension Program (SLEP) as well as other improvements that seek to reduce operations and support costs (O&S) and increase capabilities [Ref. 1]. The increased requirements are the result of doctrinal concepts that call for the CH-53E to operate over the horizon with heavier loads than it is currently capable of transporting. For example, current Marine Corps doctrinal publications, Operational Maneuver from the Sea (OMFTS) and Ship to Objective Maneuver (STOM), require that the CH-53E transport the seven-ton Medium Tactical

Vehicle Replacement (MTVR) over the horizon to provide prime mover support for artillery assets [Ref. 4]. Balancing requirements such as these and the costs to meet them will be critical, since the initiative is, as of yet, unfunded. Which leads to the objective of this thesis: develop flexible programmatic and contractual responses to meet a range of funding possibilities that maximize user satisfaction and utility.

B. RESEARCH OBJECTIVE

This research evaluated the acquisition management issues associated with the proposal to "modernize" the United States Marine Corps' fleet of CH-53E helicopters. For the purposes of my research, "modernization" is defined as a means of retarding and managing the aging process, as well as expanding the current system capabilities. A cost-effectiveness analysis was used to evaluate requirements and develop programmatic and contractual options based on possible resource limitations. Those options, and the insight provided by the cost-benefit analysis, form the foundation of tailored acquisition strategies and contracting plans that provide an efficient and effective means of meeting program objectives. This research will develop cohesive yet flexible responses, to include business and support strategies, which meet the asymmetric challenges of the current acquisition environment.

C. RESEARCH QUESTIONS

1. Primary Research Question

What are the critical program management and contracting issues involved in generating an acquisition strategy for the CH-53E helicopter modernization and how can a cost-effectiveness analysis enhance the success of that strategy?

2. Secondary Research Questions

- What are the essential elements of the CH-53E modernization proposal?

- What are the relevant benefits and costs of modernization and how do different approaches to modernization affect those benefits and costs?

- How can the CH-53E modernization program exploit opportunities for innovation made available in the 2001 rewrite of the DoD 5000 series?

- How can the acquisition approach, risk mitigation, business strategy, support strategy, and program management portions of the acquisition strategy be tailored to insure success of the modernization program?

- What contracting plan, to include vehicle type and incentive arrangement, is best suited for the modernization program?

- How can study of the CH-53E modernization acquisition strategy and contracting plan provide insight to other acquisition managers faced with the challenges of aging aircraft?

D. SCOPE AND ORGANIZATION

The scope will include: (1) a review of the current status of the Marine Corps CH-53E fleet and its proposed role in future warfighting doctrine; (2) a review of the critical elements of the proposed CH-53E modernization plan; (3) an explanation of the metrics and assumptions used to develop the cost-benefit analysis framework; (4) a cost-benefit analysis of the proposed CH-53E modernization program; (5) an evaluation of potential CH-53E modernization program options based upon various resource constraint levels; (6) an analysis of program options in order to develop a tailored, flexible acquisition strategy and contracting plan that meets program objectives; and (7) a presentation of a comprehensive acquisition strategy and contracting plan. The thesis will conclude with any relevant suggestions or recommendations for similar aviation program initiatives.

This thesis is organized into five chapters. These progress logically, providing the reader first with relevant background information and then delving into the cost-effectiveness analysis of the proposed modernization elements. Discussion and analysis then focuses on using that information to develop potential acquisition strategy and contracting options. Finally, conclusions are drawn and recommendations are made for possible application to other aging aviation systems faced with similar challenges.

Chapter I is the thesis introduction.

Chapter II presents background information on the CH-53E helicopter, its missions, roles and requirements, the program description, and modernization element descriptions.

Chapter III provides the framework and assumptions used in the cost effectiveness analysis, explains the decision support software used, describes the cost and benefit data used and explains how it was gathered. Finally, the chapter outlines the results of the cost-effectiveness analysis and how the decision support software can be updated and modified to support programmatic decisions as the program progresses.

Chapter IV synthesizes the cost-effectiveness analysis data and conclusions with the literature search materials to develop acquisition management and contracting options for a flexible and responsive acquisition strategy. Key elements of this are the business and support strategies.

Chapter V infers possible lessons that can be applied to other aviation systems from the body of this work. Additionally, this chapter presents answers to the research questions posed earlier as well as identifying areas for future research opportunities.

E. METHODOLOGY

The methodology used in this thesis research consisted of the following steps.

1. Conducted a comprehensive literature search of books, magazine articles, CD-ROM systems, government reports, Internet-based materials and other library information resources.

2. Collected cost-effectiveness analysis data from Logistics Management Decision Support System (LMDSS), Naval Air Systems Command (NAVAIR) Cost Department, the H-53 Program Office (PMA-261), the Center for Naval Analyses (CAN) Marine Aviation Requirements Study (MARS), and user functional area experts.

3. Conducted a cost-effectiveness analysis using Logical Decisions® for Windows™ in order to assess and prioritize CH-53E modernization requirements. Measures of costs included dollar expenditure, time to develop and field the solution, and any increased infrastructure and support requirements. Benefits included increased capabilities/performance, greater efficiency, reduced operations and support costs, and greater commonality and interoperability.

4. Conducted interviews either in person, or by telephone, with acquisition professionals and functional area experts at NAVAIR and user commands in order to develop a full understanding of program issues and objectives.

5. Synthesized cost-effectiveness analysis information with fiscal, logistical, technical, and business considerations provided from interviews and the literature research into an acquisition strategy and contracting plan options.

F. BENEFITS OF RESEARCH

This thesis is intended to benefit Department of Defense aviation acquisition managers trying to cope with the challenges of aging aircraft. Specifically, studies such as this will continue to build the body of knowledge necessary to extrapolate management guidance for the modernization of aging aviation systems. It is the author's intention that the results of this research will also be directly beneficial and informative to the Naval Air Systems Command and specifically the H-53 Program Office (PMA-261).

II. BACKGROUND

A. INTRODUCTION

This chapter provides the requisite background information necessary to understand the current status of the CH-53E program and its role within Department of Defense (DoD) and Marine aviation. Additionally, this chapter provides a limited technical description of the planned modernization elements to facilitate later discussion of potential cost, schedule, logistical, and performance implications.

B. STATUS AND CONTEXT OF MARINE AVIATION

Recognizing the potential savings of migrating towards common aircraft to meet multi-service requirements, the Joint Requirements Oversight Council (JROC) Review Board tasked the Joint Staff to study the feasibility of establishing a Joint Advanced Rotorcraft Technology (JART) Office similar to the Joint Advanced Strike Technology (JAST) Office that was the early incarnation of the Joint Strike Fighter (JSF) Program. Although the JROC agreed that there was value in establishing the JART Office, service representatives delayed its initiation because of insufficient funding [Ref. 5]. Nonetheless, the JROC commissioned a study called the Overarching Rotorcraft Commonality Assessment (ORCA), to determine the opportunities for joint rotorcraft and when they would likely be required [Ref. 5]. Looking at the heavy lift mission area, ORCA found that the Army's current initiative to upgrade their CH-47 Chinooks to the Improved Cargo Helicopter (ICH) or CH-47F would satisfy their requirements until approximately 2020 [Ref. 6]. The Marine Corps, realizing that a new aircraft to replace the CH-53E was fiscally infeasible, had tentatively planned a Service Life Extension Program (SLEP) to prolong its service life until a joint replacement could be fielded.

Thus, the 2020-2025 timeframe would be the first opportunity to pursue a joint heavy lift replacement, tentatively labeled the Joint Common Lift (JCL).

In order to fully grasp the challenges facing program managers of aging aircraft, a clear picture of the surrounding landscape must be described. For the CH-53E, that entails describing Marine aviation and its role and future within the Department of Defense. The U.S. Marine Corps, like its sister services, is currently coping with the effects of an aging fleet of aircraft. In a recent *Marine Corps Gazette* article titled "Transforming Marine Aviation" [Ref. 7], Deputy Commandant for Aviation, Lieutenant General Fred McCorkle, describes a neckdown strategy for the number of systems currently fielded and supported by the Marine Corps (See Figure 2.1). For example, the Joint Strike Fighter (JSF) is slated to replace both the AV-8B and F/A-18 fleet within the Marine Corps fixed wing community. Other systems, such as the AH-1W Super Cobra and UH-1N Huey, are being upgraded. Still others are being recapitalized by the purchase of new variants of the same aircraft currently fielded. For example, the KC-130J Hercules is set to replace the KC-130F/R models. Most relevant to this research is the MV-22 Osprey, the medium lift replacement for the CH-46E Sea Knight and CH-53D Sea Stallion, because of the similarity of missions flown by the MV-22 and the CH-53E. Currently however, the heavy lift replacement for the CH-53E is yet to be described or defined other than it will need to be available for fielding in the 2025 timeframe.

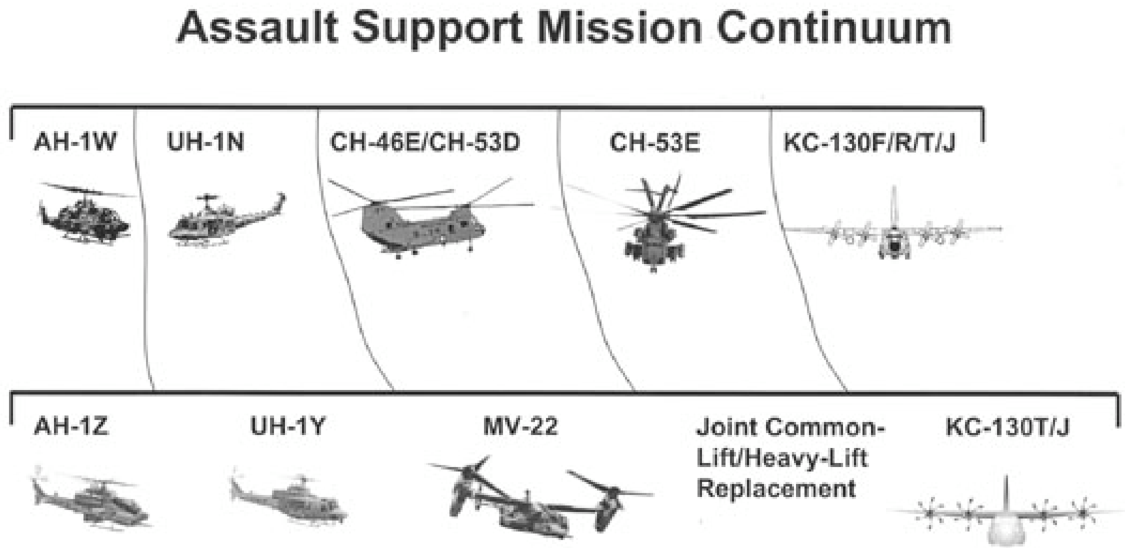

Figure 2.1 Marine Corps Assault Support Platform Neckdown Strategy [After Ref. 7]

While the Operational Requirements Document (ORD) for the CH-53E Mid-Life Upgrade (which calls for a SLEP) was approved in 1992, the program remained unfunded due to competing requirements for Marine aviation dollars. Given the number of programs competing for funding, any initiatives to modernize the CH-53E must plan to be fiscally conservative. Since most of the Marine Corps' fleet of aircraft will be modernized or replaced over the next two decades, to meet projected future requirements, securing the funding to support yet another program is a difficult proposition. The budgetary constraints created by already established programs, such as the MV-22 Osprey and the H-1 Upgrade, pose the greatest hurdle to CH-53E modernization.

C. THE CH-53E SUPER STALLION

1. Aircraft Description

Sikorsky Aircraft Corporation (SAC) of Stratford, Connecticut, a subsidiary of United Technologies Inc, manufactures the CH-53E. When manufactured and sold for export the helicopter is referred to as the S-80. The CH-53E Super Stallion used by the Marine Corps has a single main rotor and tail rotor and is powered by three General

Electric gas turbine turboshaft engines. There are seven main rotor blades and four tail rotor blades. The main rotor blades and tail pylon are capable of folding for ease of movement and stowage during shipboard operations.

Fuel is stored internally in the sponsons on either side of the aircraft as well as externally in two jettisonable auxiliary fuel tanks. The aircraft is also capable of aerial refueling utilizing a low-speed drogue deployed from a KC-130 refueling aircraft. The primary structure of the aircraft is comprised of lightweight aluminum alloy, steel, and titanium. The skin of the aircraft is fashioned primarily from fiberglass and Kevlar®. The landing gear is a retractable tricycle-type with two wheels on each landing point. The cabin can seat up to 55 troops utilizing seats along the wall as well as centerline seats. Approximately seven standard-sized pallets can be stored inside the cabin and can be loaded using a hydraulically actuated ramp and winch. [Ref. 8]

The aircrew to operate the CH-53E includes, at a minimum, two pilots and a crew chief, and typically includes an aerial observer. The current communication and navigation avionics suite remains much as it was when delivered on the original aircraft, but is not integrated as a whole. Recent improvements include a Global Positioning System (GPS) receiver, new AN/ARC-210 V/UHF Radios (two), and a second-generation navigation Forward Looking Infrared (FLIR) system. Performance and flight instruments are a combination of analog and pitot-static instruments. Table 2.1 provides aircraft dimensions and performance specifications. Figure 2.2 is a graphical depiction of the aircraft (the lower drawings depict the U.S. Navy variant MH-53E). [Ref. 8]

Table 2.1 CH-53E Super Stallion Aircraft Specifications [After Ref. 8]

CH-53E Dimensions, External

Main rotor diameter	79 ft 0 in
Main rotor blade chord	2 ft 6 in
Tail rotor diameter	20 ft 0 in
Length overall: rotors turning	99 ft 0½ in
rotor and tail pylon folded	60 ft 6 in
Fuselage: Length	73 ft 4 in
Width	8 ft 10 in
Width overall, rotor and tail pylon folded:	28 ft 5 in
Height: to top of main rotor head	17 ft 5½ in
tail rotor turning	29 ft 5 in
rotor and tail pylon folded	18 ft 7 in
Wheel track (c/l of shock-struts)	13 ft 0 in
Wheelbase	27 ft 3 in

CH-53E Dimensions, Internal

Cabin: Length (rear ramp/door hinge to fwd bulkhead)	30 ft 0 in
Max width	7 ft 6 in
Max height	6 ft 6 in

Weights and Loadings

Weight empty:	33,228 lb
Internal payload (100 n mile radius):	30,000 lb
External payload (50 n mile radius):	32,000 lb
Max external payload:	36,000 lb
Max T-O weight	
internal payload	69,750 lb
external payload	73,500 lb

Performance CH-53E at T-O weight of 56,000 lb

Max level speed at S/L	170 kt (196 mph)
Cruising speed at S/L	150 kt (173 mph)
Max rate of climb at S/L 25,000 lb payload	2,500 ft/min
Service ceiling at max continuous power	18,500 ft
Hovering ceiling at max power: IGE	11,540 ft
OGE	9,500 ft
Self-ferry range, unrefuelled, at optimum cruise condition for best range:	1,120 n miles

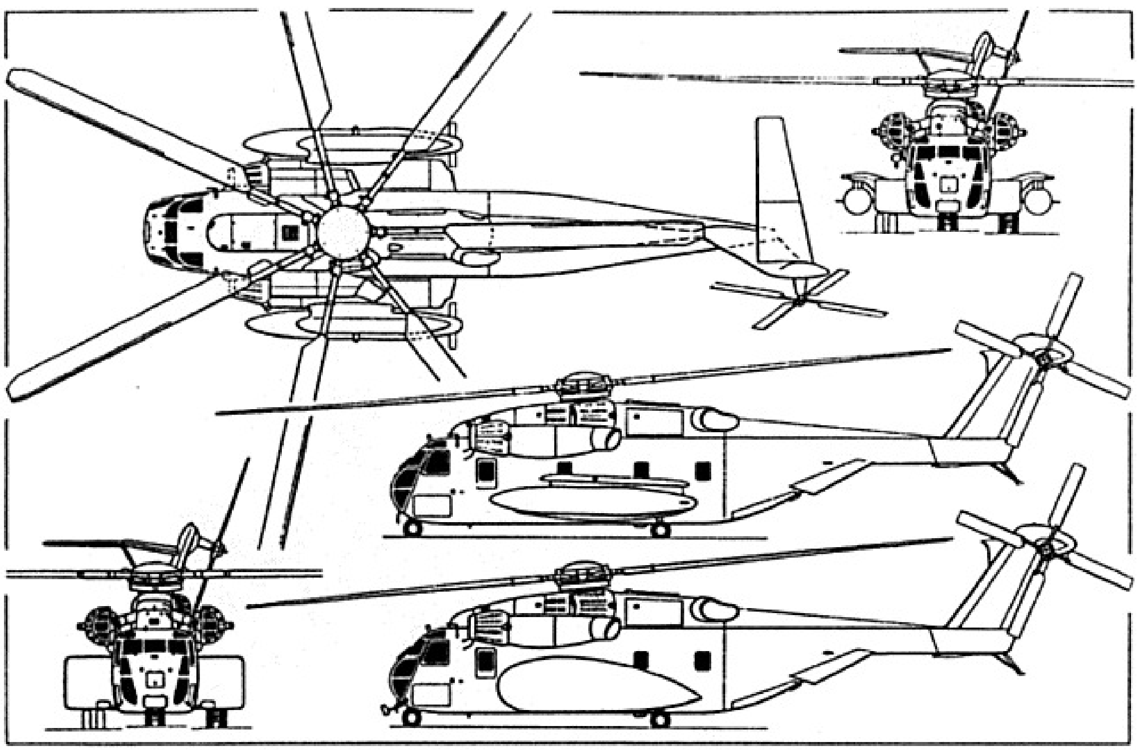

Figure 2.2 CH-53E Super Stallion Aircraft [After Ref. 8]

2. Program Description and History

The Program Office supporting the CH-53E (PMA-261) also manages the Navy variant MH-53E, the CH-53D (an older twin-engine variant slated for replacement by the MV-22 Osprey) and the Executive Helicopter Program which includes a variety of specially-equipped helicopters flying in support of the President at Marine Helicopter Squadron One (HMX-1). There are currently nine Marine Corps CH-53E squadrons or Marine Heavy Helicopter Squadrons (HMHs); six active duty squadrons, two reserve squadrons, and one training squadron. Two active squadrons and the training squadron are based at Marine Corps Air Station (MCAS) New River in Jacksonville, North Carolina. The remaining four active duty squadrons are stationed at MCAS Miramar in San Diego, California. One reserve squadron is based at Edwards Air Force Base in Lancaster, California the other is located at Willow Grove Joint Reserve Base outside of Philadelphia, Pennsylvania. Each active duty squadron's table of equipment (T/E) calls for 16 aircraft, the training squadron calls for 15 aircraft, and the reserve squadrons call for eight aircraft each [Ref. 9]. Current levels are slightly higher due to lower than expected attrition rates.

H-53E development began in 1973, and the first aircraft was delivered to the Marine Corps in 1981. A majority of the aircraft were funded and delivered through 1993, with a more sporadic delivery schedule continuing until receiving the final aircraft in October 1999. Sikorsky Aircraft Corporation (SAC) was then in negotiations with the Turkish government to purchase eight S-80Es and kept the production line open in anticipation of a contract. However, the Turkish government was unable to secure funding for the purchase and the deal fell through, at least for the time being [Ref. 10].

Sikorsky is continuing to keep the production line "warm" in hopes of negotiating a sale, but the future fate of the production line is uncertain at this point.

Since the final CH-53E was delivered to the Marine Corps in 1999, the program has shifted priorities to sustainment. Now considered a legacy system, the Program Office for the H-53E is only staffed with the resources and personnel to continue with minor upgrades. Approval of a large-scale modernization would require significantly more personnel. Recent and ongoing improvements and initiatives include an Integrated Mechanical Diagnostic/ Health Usage Monitoring System (IMD/HUMS) designed to detect failures without mandating numerous hourly inspections, thereby reducing Operation and Support (O&S) costs, and a Ground Proximity Warning System designed to enhance safety and pilot situational awareness through a warning system coupled with various sensors. While these improvements are important, they fail to fully address the deteriorating effects time has on the aircraft and represent a relatively small monetary investment.

In order to determine the material condition of the fleet, a Service Life Assessment Program was initiated once the average fleet aircraft reached 3,500 hours. The results of that assessment indicated that major airframe components would reach their fatigue life limits at approximately 6,120 hours. Data on past and forecasted utilization rates indicated an average of 18.9 flight hours per month per aircraft [Ref. 1]. Based on this data, projections were made to determine when significant numbers of aircraft would reach their fatigue life limits and have to be either retired or refurbished through a Service Life Extension Program. The results of those projections are depicted in Figure 2.3, and show that in the year 2011, the number of aircraft requiring remanufacture or retirement increases dramatically.

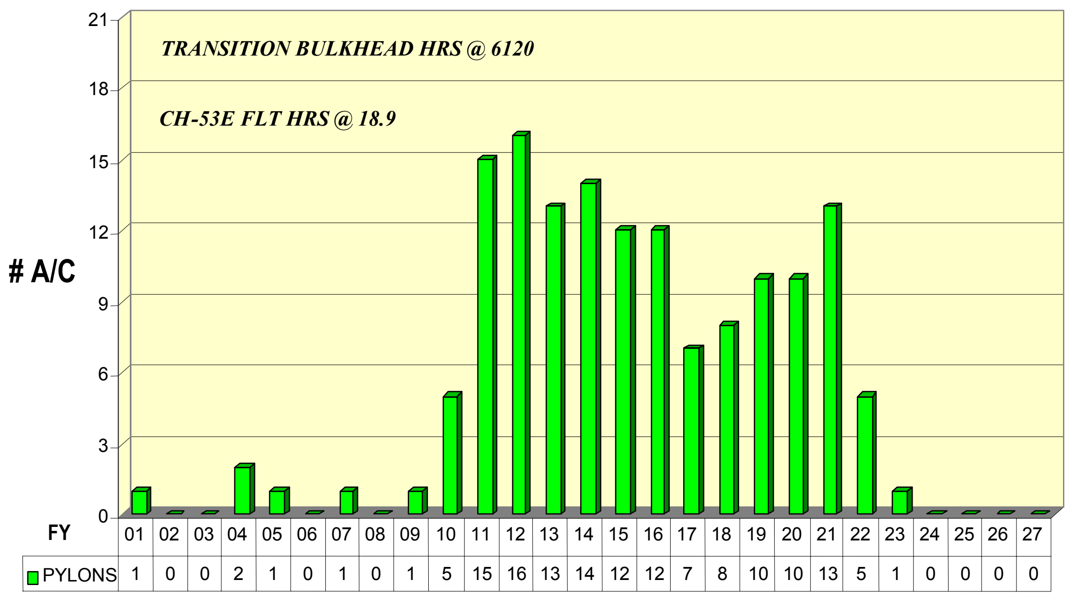

Figure 2.3 CH-53E Projected Retirement Schedule [After Ref. 11]

The realization that the current fleet of CH-53Es would not remain a viable asset until they could be replaced by the JCL initially gave rise to the SLEP initiative and later the CH-53E modernization plan. The SLEP seeks only to remanufacture fatigued airframe components, while the modernization plan calls for much more substantive improvements in both performance and reduced O&S costs. Both plans initially called for the modernization of approximately 140 of the 165 CH-53Es currently in service. That number was later reduced to 111 in order to reflect the planned conversion of the two reserve squadrons to MV-22s. However, both plans are unfunded and now must compete with other Marine aviation programs to gain funding support. Although the SLEP alone allows for the CH-53E fleet to remain operational, it fails to maintain operational parity with other combat aviation platforms, and is therefore seen as a less than desirable option by users and program managers. Initial program estimates indicated that program initiation would have to begin by FY 2004 to meet the "bow wave" of aircraft requiring remanufacture or retirement [Ref. 12]. Preliminary cost estimates placed the price tag for modernization at approximately $1.5 billion, with a target unit/aircraft cost of $21 million [Ref. 13].

D. MISSION ROLES AND REQUIREMENTS

1. Past and Present

As a heavy lift helicopter the CH-53E's primary mission in the Marine Corps is transporting heavy equipment and supplies during the ship-to-shore movement of an amphibious assault and during subsequent operations ashore [Ref. 14]. Secondary missions include transporting combat troops (exclusive of the initial assault wave) and the tactical recovery of aircraft and equipment. However, the changing capabilities of other Marine Corps assault support aircraft and changing doctrine and employment has migrated the CH-53E away from its primary mission of heavy lift.

Original design specifications called for the CH-53E to be capable of lifting a 16-ton load at sea level, transporting it 50 nautical miles and returning [Ref. 14]. The specification reflects past expectations of the sort of missions a heavy lift helicopter would perform in support of an amphibious assault. While this capability still exists today, most operations call for much greater standoff from the objective area, which increases the amount of fuel the helicopter must carry and reduces the weight of the load it can lift. Additionally, the temperature and atmospheric conditions assumed in setting the CH-53E 16-ton load capability are more forgiving than the prevailing conditions in which the helicopter has been used since its introduction to the Fleet Marine Forces (FMF). The cumulative result is that the helicopter appears to be quite capable on paper;

however, actual operations often call for the aircraft to perform in missions and/or environments that exceed the helicopter's current capabilities.

Currently, CH-53Es are deployed as part of an Aviation Combat Element (ACE) within a Marine Expeditionary Unit (MEU). MEUs are the smallest version of the Marine Air Ground Task Force (MAGTF). MEUs are self-contained task-organized units built around an infantry battalion and are embarked on U.S. Navy amphibious ships, organized into an Amphibious Ready Group (ARG). ARGs typically include three air-capable ships, one of which is a helicopter carrier that serves as a sea-borne base for the ACE. The ACE is built around a Marine Medium Helicopter squadron (HMM, currently comprised of CH-46Es that are to be replaced by MV-22s) that is augmented by detachments from a Marine Light/Attack Helicopter squadron (HMLA, comprised of AH-1Ws & UH-1Ns), a fixed-wing Marine Attack squadron (VMA, comprised of AV-8Bs), and a HMH squadron (CH-53Es). A typical ACE detachment of CH-53Es usually includes four aircraft.

While the CH-46E is the primary combat assault troop carrier in the Marine Corps, an aging airframe and degraded engine performance often make it difficult or impossible for this aircraft to perform its mission. As a result, the CH-53E has and will continue to fill this gap in capability until the MV-22 becomes operational. Indeed, the CH-53E's capability with regard to lift capacity, speed, range and endurance has made it one of the most flexible tools available to MAGTF Commanders. However, by compensating for the performance deficiencies of the CH-46E, the CH-53E infrequently performs its primary heavy lift mission. High density-altitude ambient conditions (where engine and aerodynamic performance are degraded) often reduce power margins when lifting heavy loads, leaving little room for error. Additionally, conspicuous problems with the helicopter's external cargo hook system, resulting in damage to or loss of expensive equipment, has undermined aviation leader's willingness to sanction lifting heavy equipment for strictly training purposes. Yet the trend leading the CH-53E away from its primary heavy lift mission appears likely to change. With the heralded, yet delayed arrival of the MV-22, potentially a more capable assault support platform than the CH-46E, the CH-53E will likely be relieved of transporting combat assault troops and return to its primary duty as the Marine Corps' heavy lift platform.

2. The Future

While the nature and location of conflicts in the future is unclear, it seems likely that advances in weapons' range and accuracy will require U.S. forces to engage their enemies or provide support from a safer distance. Yet as our force becomes more technologically advanced it also becomes more reliant on robust logistics support. Providing robust logistics support over greater distances will demand even greater capabilities from Marine Corps heavy lift assets. Additionally, the greater speed of movement afforded by other assault support aircraft, such as the MV-22, will allow Marines to quickly displace further away from their point of origin. That displacement speed must be matched by logistical support speed that can only be provided by transporting heavy cargo and equipment externally. Operational concepts, such as Operational Maneuver from the Sea (OMFTS), Ship-to-Objective Maneuver (STOM), and Sea-Based Logistics (SBL), determine the broad requirements the Marine Corps seeks to meet, and each requires the means to provide fast, flexible support over distances and in conditions that currently exceed the capabilities of the CH-53E or any Marine aviation platform.

Recently, the Marine Corps commissioned the Center for Naval Analyses (CNA) to conduct a study to determine the appropriate size, composition, manning, force structure and capabilities for Marine aviation in 2015. Aptly titled the Marine Aviation Requirements Study (MARS), the study analyzed three activity level scenarios; peacetime deployment rotation, MEU ACE operations, and a Major Theater War (MTW) scenario. The peacetime scenario focused on the manning and force structure required to support regular deployments and training, as well as the capability to surge to meet real-world contingencies. The MEU ACE portion analyzed capabilities and mix of aircraft required to support the range of MEU ACE missions. Not surprisingly, the report concluded, "[t]here will continue to be heavy equipment, which the V-22 can not transport, in the MEU…. It makes sense to continue to include some heavy lift transport capability (CH-53Es) in the MEU ACE." [Ref. 3] The report not only recognized that the heavy lift requirement would remain, but that the CH-53E would have to be upgraded or improved to meet the requirements of the 2015 MEU ACE.

A portion of the MTW scenario analyzed the assault support assets necessary to support aerial insertion of a Regimental Landing Team (RLT) as part of an amphibious assault. Table 2.2 summarizes the how troops and equipment are transitioned ashore by the MV-22s and CH-53Es. Note the significant number of external lifts required (74%) and that 62% of all MV-22 lifts were external loads. Due to their aerodynamic instability, most external loads are flown at 100 knots, so the MV-22's speed advantage is sacrificed when it carries external loads. Additionally, the study noted that the CH-53E moved, on average, two short tons more per lift than an MV-22 in the MTW scenario.

With the expanded capabilities of the modernized CH-53E described later, that advantage would be increased to more than ten short tons per lift. [Ref. 4]

Table 2.2 Regimental Landing Team (RLT) Air Insertion Summary [From Ref. 4]

	PAX	Vehicles	MV-22 Int. Lifts	MV-22 Ext. Lifts	CH-53E Lifts	MV-22 Sorties	CH-53E Sorties
Wave 1	1798	50	64	14	36	78	36
Wave 2	976	73	30	38	35	68	35
Wave 3	271	102	3	71	31	74	31
Wave 4	0	6	0	32	22	32	22
Total	**3045**	**225**	**97**	**155**	**124**	**252**	**124**

Summary

- **98 MV-22 and 50 CH-53E aircraft required**
- **Approximate time to complete all flights: 11.5 hours**
- **Distribution of sorties: internal lift — 26%; external lift — 74%**
- **62% of all MV-22 sorties were external lifts.**

Yet, performance enhancements are not the only requirements for the future. Modernizing aging aircraft provides the opportunity to address many problems that could not be anticipated when the system was being developed. Years of experience and data can be used to address recurring problems. Components and subsystems that are top maintenance degraders can be redesigned or replaced by more reliable ones. Indeed, improving readiness does improve performance by requiring less time and resources to accomplish a given mission. Reducing O&S costs liberates funds for other uses, such as training that also improves readiness rates. These are just some of the major expected benefits of a modernized CH-53E.

Modernizing an aging platform such as the CH-53E provides other opportunities for cost and non-cost benefits. For example, commonality of components and subsystems takes full advantage of economies of scale when making purchases and reduces inventories and the warehouse space required to maintain and support a system. Greater commonality, like that obtained in the H-1 upgrade program, is forecasted to save $897 million (FY96 constant dollars) over the life of the systems [Ref. 5]. Another common problem of aging aircraft, like the CH-53E, is avionics obsolescence and the accompanying lack of interoperability. Improving modern aviation systems' ability to communicate and share data with other systems on the battlefield, as well as between components within the same airframe, can greatly enhance mission performance and safety. This requirement is somewhat unique however, because the benefits are shared across platforms, which attracts new stakeholders to participate in defining modernization requirements.

Identifying and prioritizing requirements in order to allocate sufficient resources to meet those requirements is a critical first step towards insuring programmatic success. Clearly, as CH-53E program managers contemplate the potential benefits of modernizing the system, one of their greatest challenges will be to strike the proper balance between, satiating the user's performance requirements on the one hand and, the bureaucrat's cost savings requirements on the other, without jeopardizing both. Using cost effectiveness analysis as a tool to ascertain how that balance might be struck, will be the focus of the subsequent chapters.

E. MODERNIZATION ELEMENT DESCRIPTIONS

This section describes the nature of the currently proposed modernization elements, the technologies upon which they rely, and some of the potential risks that may arise in pursuing them.

1. Service Life Extension Program (SLEP)

As discussed earlier, a SLAP was conducted to determine which areas of the airframe were most likely to fail, and when, to determine what portions of the airframe would have to be replaced. The CH-53E SLAP determined that the pylon transition lug area had the shortest fatigue life (6,120 flight hours) and would require replacement, as would the cabin sections around the main transmission (see Figure 2.4). Improving the cabin structure in the vicinity of the main transmission could increase maximum gross payload by 5000 pounds and thereby take full advantage of the performance benefits provided by the new engines and rotor blades described below. Other work that will be included in the SLEP modernization element is replacing of aircraft wiring that has become brittle and unreliable over time.

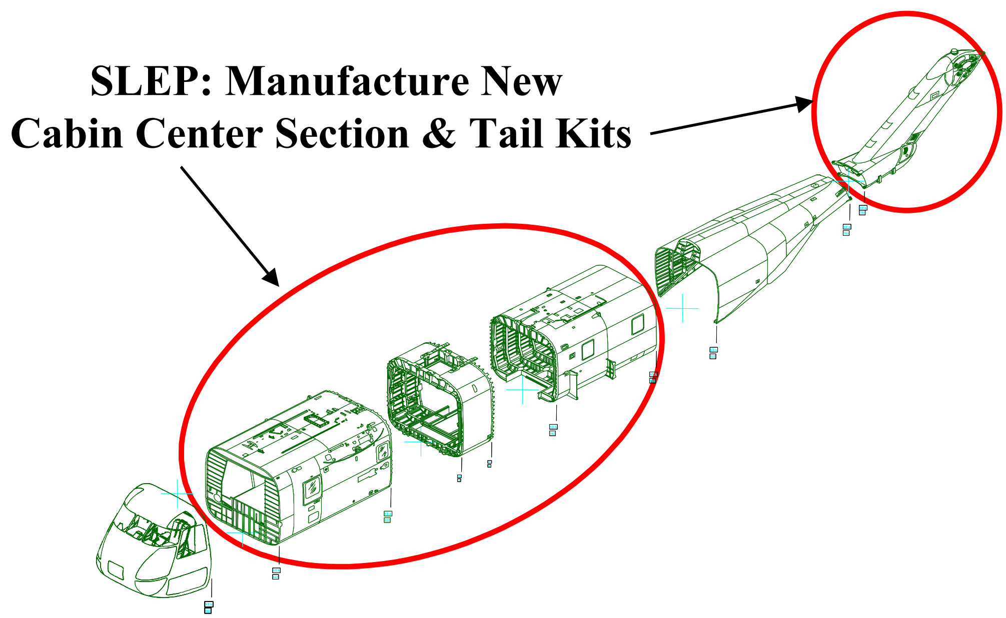

Figure 2.4 CH-53E SLEP: Areas Requiring Airframe Structural Work [After Ref. 11]

Of all the modernization elements, the SLEP is the most essential; without it the Marine Corps' fleet of CH-53Es will not survive until 2025. Yet, while it is simple to justify undertaking the SLEP, the procedure itself is by no means simple. After 6,000 flight hours, tens of thousands of maintenance actions, exposure to disparate climates and dissimilar flight operations, significant losses in commonality from the baseline that existed when the aircraft came off the production line are inevitable. This can produce problems when trying to apply production line techniques with standardized components. Tolerance stack-up, where parts that meet individual design specifications fail to fit into the larger system, is a distinct possibility for some SLEP structural components, as are planning difficulties arising from the varying configurations of aircraft entering SLEP [Ref. 15]. For this reason, establishing and defining the baseline from which SLEP work will begin can be somewhat problematic and lead to greater cost and schedule risk. However, the technology to perform SLEPs is relatively stable and there is ample historical data on other helicopters that have undergone SLEPs. Despite the frequency with which SLEPs are performed, program managers must be cautious not to assume away potential sticking points in the SLEP process.

2. Engines

Current modernization plans call for replacing the existing General Electric T64-GE-416/A engines with engines common to other Marine or Navy aircraft, like the Rolls-Royce Allison AE1107C. The AE1107C, is used in the MV-22 and KC-130J aircraft. This engine can provide a significant increase in performance from the existing engine, and provides greater commonality among Marine aviation platforms. Additionally, as Figure 2.5 shows, initial drawings indicate that engine compartments would require limited modification to install the AE1107C. As it is currently configured, the CH-53E is engine-limited, which is to say that the engines do not produce enough horsepower to meet or exceed the transmission's limits. This excess capacity in the transmission is exploited with the addition of the AE1107C, making the CH-53E a transmission-limited helicopter, like most others serving the U.S. military. Due to the strength of the drive train, initial projections only foresee the requirement to make interface modifications rather than a complete redesign.

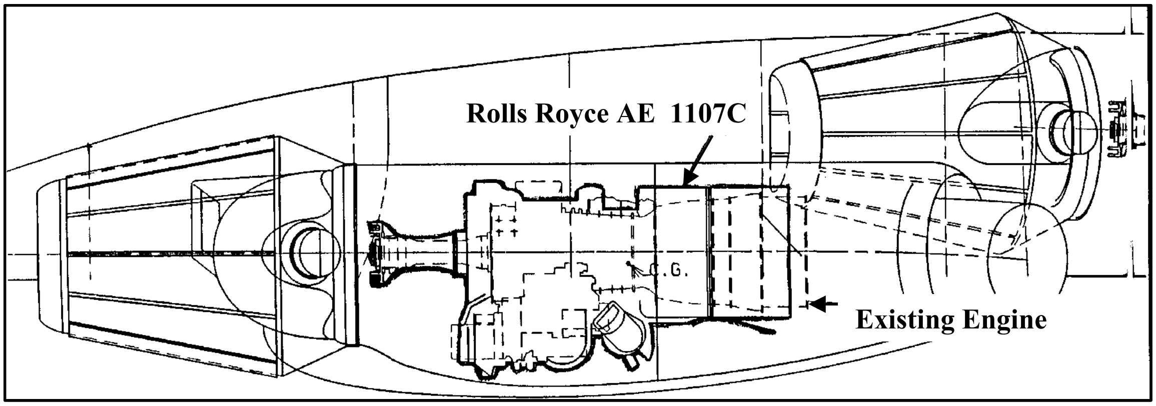

Figure 2.5 Outline of Rolls Royce AE 1107C Engine in CH-53E Cowling [After Ref. 11]

As depicted in Figure 2.6, the total performance enhancements realized by adding the AE1107C are impressive, particularly when combined with the new main rotor blade that will be described later. Despite the quantum leap in performance, adoption of the AE1107C does not come without risk. Notably, the engine is a new design with a short performance history, although initial data demonstrates reliable performance. Additionally, while the integration prospects appear positive, further testing and evaluation could unearth unforeseen problems because the engine generates greater horsepower. While not all-inclusive, these are just some of the potential programmatic risks faced by managers and decision-makers considering the adoption of the AE1107C as the new engine for a modernized CH-53E.

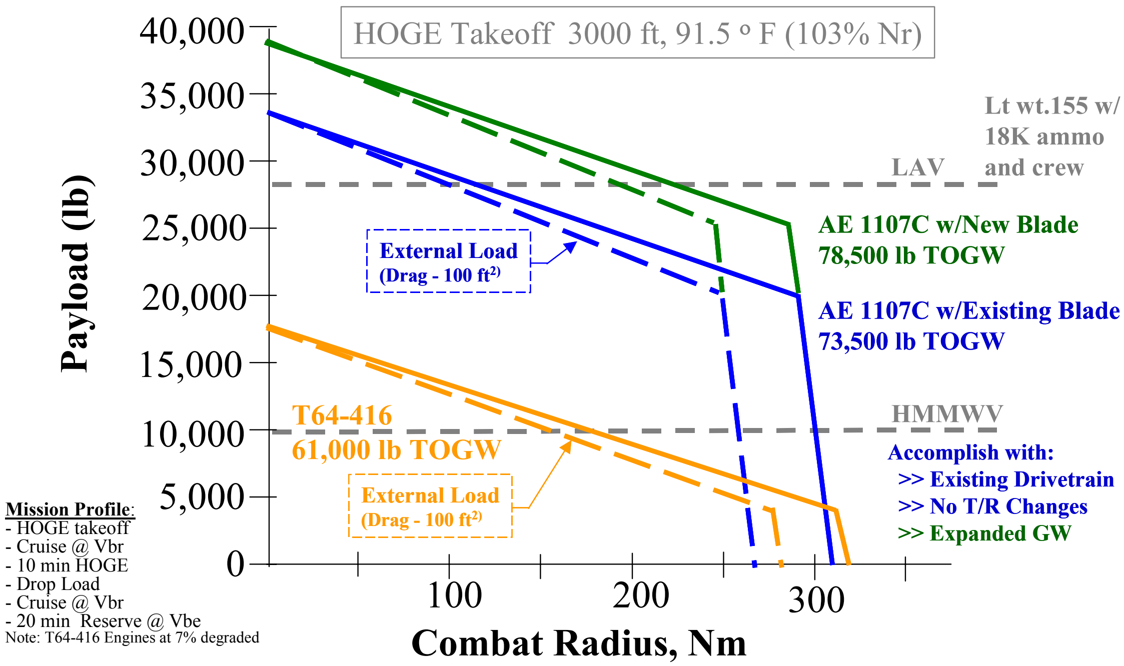

Figure 2.6 CH-53E Performance Capabilities (New Engines and Blades) [After Ref. 11]

The final piece of the engine modernization element involves a contractor logistics support (CLS) arrangement for maintenance of the engine above the organizational level. In the case of the Rolls-Royce AE1107C, the trademark, Power-by-the-Hour®, recognizes the specific CLS arrangement. Under this arrangement, which is currently being used by the V-22 Program, engines are purchased by the Marine Corps from Rolls Royce under one agreement. Under a separate agreement, the Marine Corps pays for intermediate and depot level engine support based on usage. Usage is measured by the post-flight downloading of engine performance information through a Full Authority Digital Electronic Control (FADEC) System which records engine performance parameters. These data are then converted into a standard unit of measure called an Equivalent Specification Mission Hour (ESMH) that serves as the basis for support charges. Since most accounting for flight operations is tied to the flight hour, an estimate of the ratio of ESMH to flight hour must be made in order to predict the cost of the arrangement. Because the CH-53E has migrated away from its initial role of heavy lift, but is likely to return to that mission in the future, using historical data on engine usage may not accurately reflect future usage, leading to both erroneous estimates of the ESMH to flight hour ratio and potentially serious cost overruns. [Ref. 16]

3. Improved Main Rotor Blade

Based on a blade for Sikorsky's S-92 Helibus helicopter, the proposed blade is an all-composite, swept anhedral tip design (See Figure 2.7) that would provide an additional 4000-6000 pounds of lift and allow for faster airspeeds before the onset of blade stall [Ref. 11]. The improved blade also addresses maintenance problems with the current blades that utilize a pressurized honeycomb structure. Since the basic design of the blade is proven, there is little technical risk involved in modifying it to support the CH-53E. However, it is unclear how the composite materials would endure exposure to the austere environments and harsh conditions in which the Marine Corps routinely operates (i.e., shipboard and desert operations). Failure to address these issues could lead to greater than expected O&S costs due to more frequent blade repairs and replacements.

Figure 2.7 S-92 Rotor Blade with Swept Anhedral Tip [After Ref. 11]

4. Elastomeric Rotor Head

The rotor head design, like the main rotor blade, is based on S-92 as well as CH-53D design and technology. The new rotor head is fashioned entirely from titanium; uses elastomeric pitch, flap, and lag bearings; utilizes a dry housing design; and incorporates an electric blade fold system (see Figure 2.8). The current design utilizes standard bearings and a hydraulic damper or "wet" head that has been very maintenance-intensive. The blade fold system on the current rotor head is hydraulic as well and has not been as reliable as was originally expected.

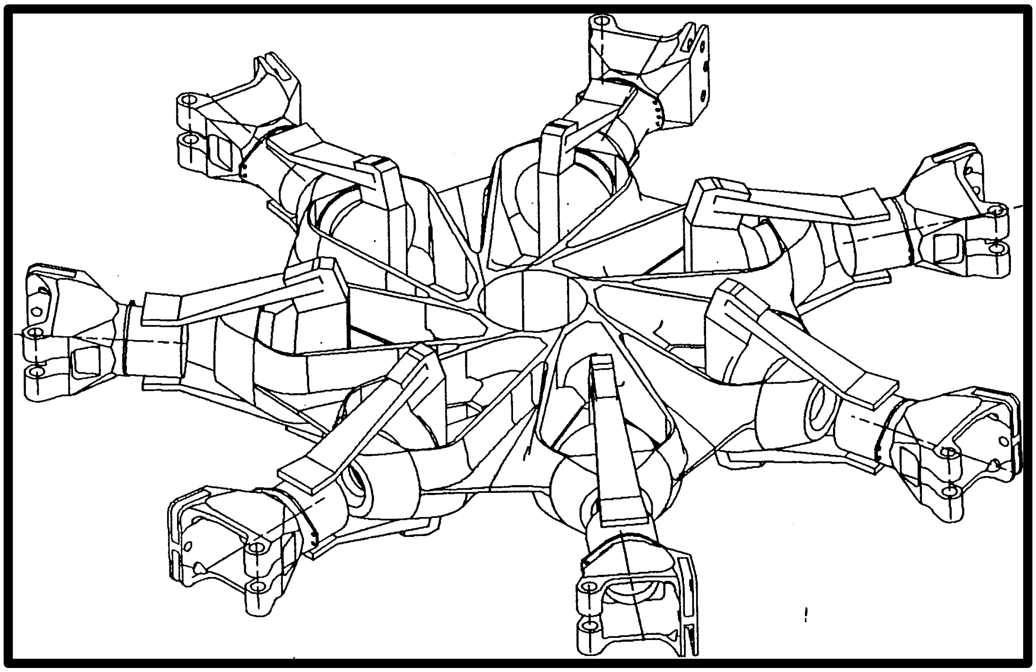

Figure 2.8 CH-53E Seven Bladed Elastomeric Rotor Head [After Ref. 11]

This modernization element is very attractive because it targets consistent maintenance degraders and therefore has the greatest potential for O&S cost savings. Additionally, both the design and technology have been proven in similar applications, decreasing the likelihood of early design or production problems. However, the loads that will be placed on the modernized CH-53E rotor head are significantly higher than those applied to either the S-92 or CH-53D rotor heads and could produce unforeseen hazards.

5. Common Cockpit

The exact design and makeup of the common cockpit has yet to be defined, but current propositions seek to maximize commonality with other Marine aviation assault support systems (MV-22 or UH-1Y). Sikorsky has proposed the "international" glass cockpit used in the S-80E that incorporates much of the latest avionics functionality, such as moving map displays. Regardless of the design finally selected, improvements should address the problems of avionics obsolescence, data exchange, commonality, and interoperability. Another goal is to improve pilot field of view by reducing the size of the center console in a manner similar to the S-92 console depicted in Figure 2.9.

Figure 2.9 Common Cockpit (S-92 shown here) [After Ref. 17]

Because the nature and design of the common cockpit remains fluid, it is still difficult to ascertain all the potential risks that may arise. Clearly, as with any electronic endeavor, one of the greatest risks is in the area of software integration. Utilizing a group of components that has been used in other platforms may alleviate some of the uncertainty with respect to both cost and schedule.

6. Improved Cargo Hook System

The improved cargo hook system element seeks to address two primary issues, the first being the lack of reliability and maintainability in the current system. The second is to ensure that the new system is capable of handling the heavier and larger loads made possible by engine and blade improvements. Like the common cockpit modernization element, the details of this modernization element are yet to be defined.

The current system is an electromechanical system that allows for single or dual-point attachment of loads. Reliability problems have plagued both the single and dual-point systems and apprehension about their ability to function properly has been exacerbated by a few incidents where valuable ground equipment was damaged or destroyed. Restoring confidence among users of the ground equipment that is going be transported by the helicopter, as well as avoiding costly mishaps, is one of the overarching goals of this modernization element.

Because the particulars of this element are yet to be determined, it is difficult to accurately assess what the potential technical risks may be. However, because the current solution is unsatisfactory and there is no apparent ready solution from another platform, original design work will have to be done to produce a workable solution, thereby increasing the risks relative to the other elements that build upon existing solutions.

7. Summary and Other Potential Elements

Survivability improvements, such as armor, ballistic vulnerability improvements, an On Board Inert Gas System (OBIGS), and traditional Aircraft Survivability Equipment (ASE) have all received attention as possible additions to the modernization plan for the

CH-53E. While it is possible that they and/or others may be added at a later time, for the purposes of this study, the elements were limited to the first six described.

The use of commercial and/or readily available technologies was emphasized in each modernization element, when possible, to mitigate cost, schedule, and technical risks. This is intended to keep the cost of the entire project low; otherwise it becomes politically untenable due to the number of other valid Marine aviation requirements vying for limited funding. Despite the individual risks involved with each modernization element, integration is critical, as is maintaining the production schedule, because the CH-53E fleet will have to remain operational as the aircraft are modernized. Conversely, the synergistic rewards of the modernization elements create a more capable complete platform. Another technical issue somewhat unique to helicopters is the potential adverse effects of vibrations and their interaction or interference with the dynamic systems and components within the helicopter. Like many technical risks, these are difficult to predict and are often concealed until actual prototype testing begins. Due to the possibility of this sort of "hidden" problem, it is important to minimize other sorts of technical risks by using proven technologies, as was done in most of the modernization elements.

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III. COST-EFFECTIVENESS ANALYSIS

A. INTRODUCTION

This chapter describes how the cost effectiveness analysis model was developed and constructed. The decision support software used to support model formulation and analysis is also described and explained. Additionally, information is provided on how cost and effectiveness measures were obtained, aggregated and used in the model. Due to the early stages of the CH-53E modernization effort, not all of the desired cost or effectiveness data were available, primarily because of technical and practical uncertainties. As a result, data shortfalls are discussed along with what sort of data would enhance the applicability and robustness of the model. Finally, the analysis portion evaluates the potential implications of using the cost effectiveness model as well as how the model might be improved and used by acquisition managers.

B. ALTERNATIVES AND ANALYSIS STRUCTURE

1. Modernization Configuration Alternatives

Ten alternative modernization configurations were formulated using the six elements described in the preceding chapter. While these ten alternatives are not meant to describe every potential combination of elements, they do provide a spectrum of capabilities and costs. Additionally, combinations were chosen that, in the author's opinion, were logically consistent with user needs, potential fiscal constraints and manufacturing prudence. The model is constructed such that the addition of future combinations or elements will not require an exorbitant amount of effort, although it will require regeneration and insertion of the applicable cost and effectiveness data. Table 3.1

provides a listing of the abbreviations for modernization elements and the ten alternative configurations.

Table 3.1 CH-53E Modernization Element Abbreviations and Configuration Alternatives

Modernization Element Abbreviations			
Abbr.	Element	Abbr.	Element
S	SLEP	R	ELASTOMERIC ROTOR HEAD
E	ENGINES	H	IMPROVED CARGO HOOK SYSTEM
B	IMPROVED MAIN ROTOR BLADES	C	COMMON COCKPIT

Modernization Configuration Alternatives	
1	S (SLEP ONLY)
2	S,E,B,R,H & C (ALL SIX)
3	S,E,H
4	S,E,B,H
5	S,E,B,R,H
6	S,B
7	S,B,R
8	S,B,R,C
9	S,R
10	S,R,C

To date, program office efforts to gain funding for program initiation have focused on developing a cost estimate for all modernization elements to secure funding beginning in fiscal year 2004 (FY04). That initial cost estimate was used as a basis for determining configuration development and production costs. Because the estimate reflects a complete CH-53E modernization, some element costs were inseparable and therefore were burdened on all configurations. The exact nature of the cost allocation will be discussed in the measures of costs and effectiveness section of this chapter.

Which elements are of primary concern is still a matter of some debate and is a question this study hopes to illuminate. It is already recognized that the alternatives chosen do not reflect all the possible options facing acquisition managers. Rather, the intent was to create a template that can support manager decision analysis. Therefore, modernization configurations used in this study should be viewed as representative of the range of options that may be evaluated in the future.

2. Decision Support Software and Analysis Structure

As mentioned earlier, a software package called Logical Decisions® for Windows™ (LDW) was used to aid in the organization and analysis of the data collected. LDW converts the collected data into measurements of utility to determine the most desirable alternative. The user can determine the range of utility scores; for this study the range was from zero to one, with one having the greatest utility and zero having the least. LDW uses a four-step process in its decision analysis; structure the problem, describe the alternatives, assess preferences, and rank alternatives [Ref. 18]. The second step in the process, describing alternatives, was accomplished in the previous section.

Structuring the problem involves identifying alternatives, goals and measures. For every alternative, each goal or sub-goal has a computed utility, determined by aggregating the measure levels that comprise that goal. Goals are concerns that each alternative must seek to answer. Sub-goals are aggregated into goals until a final utility is computed for the overall goal, which is then used to rank the alternatives. Measures are used to describe each alternative. They are numerical or categorical variables that characterize various aspects of a given alternative and either contribute to or detract from an alternative meeting a given goal.

Ideally, measures should be objective measurements that can be quantified with a degree of certainty, such as the tactical range of the CH-53E. LDW can also perform Monte Carlo simulations to replicate the probabilistic distribution of a range of measure levels. However, some of the requisite objective data were not available to determine an accurate probabilistic distribution for all the measures used. Therefore, subjective data derived from expert assessments was used as a proxy for the objective data and scored using categorical descriptors.

Once identified, goals and measures are then structured into a hierarchy to organize the decision problem. Figure 3.1 graphically depicts the goals hierarchy created for CH-53E modernization decision analysis. All measures (except O&S Costs) were removed to limit the size of the figure. A complete goal / measure hierarchy is provided in Appendix A.

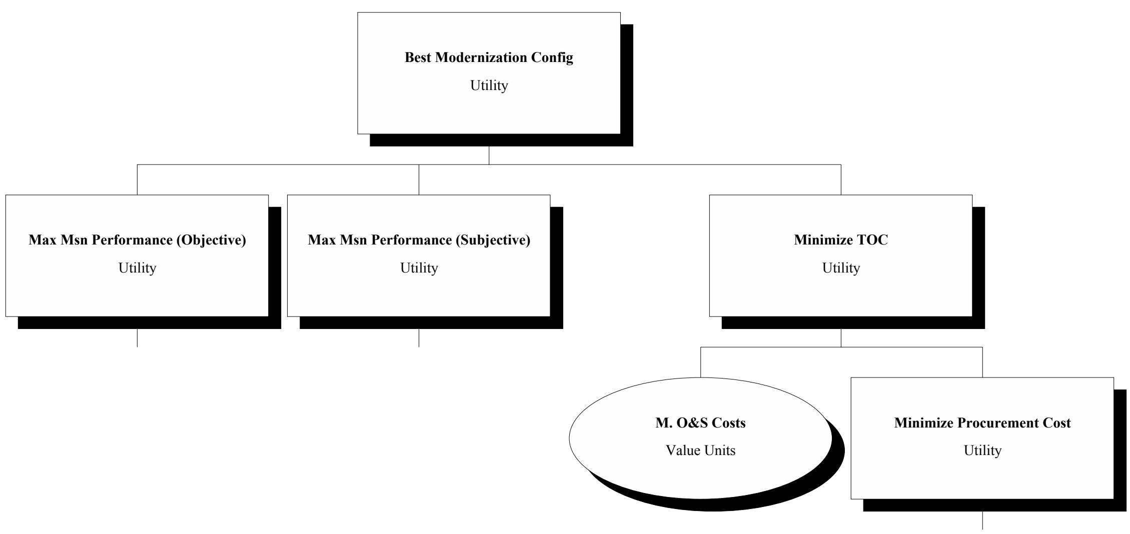

Figure 3.1 CH-53 Modernization Goal Hierarchy

The overarching goal in this case is to choose the best modernization configuration. Sub-goals include maximizing mission performance (objective and subjective) and minimizing Total Ownership Costs (TOC), which fall under the overarching goal and contribute to overall utility. A sub-goal of minimizing TOC is minimizing procurement costs. Table 3.2 shows all remaining measures and their associated goals not depicted in Figure 3.1. A detailed description of the measures chosen and how data were collected and incorporated into the model will be provided in the next section of this chapter.

Table 3.2 Remaining Measures and Associated Goals

GOAL	Max Msn Perf. (Obj.)	Max Msn Perf. (Subj.)	Min. Procurment Costs
MEASURES	Payload 3H Scenario	Assault METL	APN Account Costs
	Range 3H Scenario	Raid METL	RDT&E Account Costs
		TRAP METL	
		MEDEVAC METL	
		Spec. Ops. METL	
		NEO METL	
		Ship Ops. METL	
		Night/IMC METL	

Goals were chosen based upon their likely influence on decision-makers and measurability. Mission performance was divided into an objective and subjective goal to isolate the different types of measures. Objective measures are numeric variables of estimated performance capability. Subjective performance measures are based upon the CH-53E's Mission Essential Task List (METL) described in Training and Readiness Volume I (T&R Vol. I) [Ref. 19]. Each METL outlines the type of missions a fleet CH-53E squadron must be prepared and capable to execute. It reflects most accurately the way a CH-53E aircraft will be employed in the future. Procurement cost measures reflect estimated expenditures from the RDT&EN (Research, Development, Test and Evaluation, Navy) and APN (Aircraft Procurement, Navy) accounts for program development and execution through production.

Should CH-53E modernization become a funded program, continued testing and research will undoubtedly yield more data to expand the number of goals used in the analysis. Additional data will also more accurately predict measure levels, thereby removing some subjectivity and uncertainty that exists in this preliminary model. By continuing to refine goals and measure data, this model can continue to be used as the program progresses as a decision aid for management personnel.

The third and most critical step in the LDW decision process is assessing preferences, which involves converting measures levels to common measures of utility and assigning weights for each sub-goal and measure. The assessment step creates a preference set for a given decision-maker. LDW allows for the creation of more than one preference set to analyze how the desires of various decision-makers will affect the recommended outcome. Because several individuals will likely be involved in any programmatic decisions, a composite preference set of users (pilots) and program management personnel was created and used for this analysis. Experienced pilots were asked to provide a numerical weight characterizing the importance of each METL measure evaluated, such that they sum to one. Other weights were determined by interviews with program managers based on their individual priorities and the perceived priorities of their superiors. As new personnel become involved in the program or priorities shift, new assessments can be used to generate new preference sets that reflect changing concerns; old preference sets can also be modified accordingly.

LDW converts measure levels to measures of utility using a Single-measure Utility Function (SUF) [Ref. 18]. LDW initially assumes a linear SUF between utility and a given measure across the user specified range. However, non-linear SUFs or any break points in the measure range can be incorporated into LDW as well. With respect to cost, a linear SUF characterizes a risk neutral decision-maker. The ability to capture decision-maker risk aversion or risk seeking behavior and their valuation of each measure is a powerful tool that provides insight into which modernization elements should be the program's focus.

Assessing weights provides the scaling constants necessary to aggregate measure levels and sub-goals and determine a final ranking of alternatives. LDW uses Multi-measure Utility Functions (MUFs) to aggregate measure level SUFs and sub-goal MUFs [Ref. 18]. Each goal and sub-goal has a MUF. Weights must be assessed for every goal and measure beneath the overall goal. Weights can be assessed in a number of ways in LDW. The primary method used in this analysis was the "smarter method," which involves ranking the sub-goals and measures under a particular goal against one another. From this information LDW calculates a percentage weight for each sub-goal and/or measure such that they sum to one. These percentage weights are then displayed to the user to confirm that they accurately portray their preferences. As alluded to earlier, the other method used was the "direct assessment" method where experienced pilots were asked to assign each METL measure a numeric percentage weight that was then averaged and entered into LDW. Program management personnel also used the "direct assessment" method to assign weight to some sub-goals and measures.

The fourth and final step in the LDW process is ranking the alternatives. This process is made fairly simple, it merely involves instructing the program to compute overall utilities and rank each of the alternatives based on the measure and assessment data provided. In addition to ranking the alternatives, LDW provides some powerful analysis tools that allow the user to manipulate parts of the problem and see what affects this has on the final ranking of alternatives. These sensitivity tools will be discussed in detail in the analysis section of this chapter. Additionally, LDW allows the user to evaluate how any uncertainties and individual measure levels affected each alternative's overall utility score.

While the overall model appears somewhat simplistic, it is important to remember that the structure facilitates analysis with the data currently available. Given the limited data, the model structure captures only a portion of the complexity of the CH-53E modernization problem. Yet, as was the intent, it does provide a template that can be expanded in scope and complexity to accommodate more information as it becomes available to program managers.

C. MEASURES OF COST AND EFFECTIVENESS

1. Procurement Cost Measures

To date, a majority of the cost estimation effort on the part of the program office has focused on generating an accurate estimate of procurement costs. Procurement costs include the development and production costs for a fleet of 111 modernized Marine Corps' CH-53Es. All cost estimate measures were adjusted for inflation and calculated in millions of fiscal year 2000 dollars (FY00$M). Probabilistic distributions for each modernization configuration alternative were generated using Crystal Ball simulation software based on cost estimate data collected from the program office. Distributions were calculated separately for the development effort (funded from the RDT&EN account) and the production effort (funded from the APN account) for each alternative. These distributions were then entered into LDW, which used 1000 Monte Carlo simulation trials to determine the measure levels used in the final decision analysis. The H-53 Program Manager determined weights for the "Minimize Procurement Cost" sub-goal and the "APN Cost" and "RDT&E Cost" measures. Because risk behavior regarding cost is often driven by political realities that are not easily predicted or modeled, the linear risk neutral relationship between procurement costs and utility was used in this analysis. Specific weights for the cost measures will be discussed in the analysis section of this chapter.

The ground rules and assumptions used by the program office cost estimators in developing the Rough Order of Magnitude (ROM) estimate are provided below.

- The CH-53E Product Improvement/SLEP will be Sole-Source to Sikorsky Aircraft Corporation in Stratford, CT. All non-recurring engineering and testing as well as all recurring production and kit installations will be done at the facilities in Stratford.
- The program will include an Engine upgrade, installation of a Common Cockpit, improved M/R Blades, Elastomeric M/R Head, improved Cargo Handling System, and the original SLEP kits with improvements and design changes to increase the aircraft gross weight. The original SLEP included a T/R Driveshaft Coupling modification, redesign and installation of a new Spec-55 Wiring Harness, replacement of the Center Fuselage Cabin (Sta. 162 to Sta. 522), and replacement of the Tail Pylon. The SLEP improvements include redesigned Main Gearbox Support Structure, and redesigned Tail Pylon.
- This estimate is a "High Order ROM" and will include the Research and Development (R&D) (non-recurring and recurring) as well as the Production costs (non-recurring and recurring). It does not include an estimate of Operations and Support (O&S) costs.
- System Test and Evaluation (DT/OT) will include four (4) test units (Flight Test Articles), which will be full-up units.
- The MH-53E is not included in this analysis/estimate.
- The H-1 Upgrade program will be used as an analogous comparison for R&D/ST&E schedule as well as non-recurring design and integration for the Elastomeric M/R Head, improved M/R Blades, Common Cockpit, and Software.
- The V-22 will be used as an analogous comparison for the Engine upgrade, engine cost and integration.
- This estimate will be done in Then Year (TY) and FY00$ dollars. [Ref. 20]

In order to account for both recurring and non-recurring costs, a high and low figure was calculated for each fiscal year in which RDT&EN and APN funds were to be expended. Based on these high and low figures, a uniform distribution was created for each fiscal year and account. These distributions were then summed to determine a total cost for each account and alternative. 5000 simulation trials were run using Crystal Ball to forecast total account cost distributions for entry into LDW. The resulting total RDT&EN and APN account costs were determined to be normally distributed and were entered into LDW as such. Forecast distributions and statistics as well as the uniform distribution assumptions can be found in Appendix C. Because the program office ROM estimate is for a complete modernization (all six elements), some cost elements could not be broken out. Cost elements that couldn't be separated and attributed to a specific modernization element will be identified in the development and production cost measure analysis discussion below.

Development cost elements include the design and engineering work for each of the modernization elements, Flight Test Articles (FTAs), Special Tooling/Special Test Equipment (ST/STE), System Test & Evaluation (ST&E), Systems Engineering/Program Management (SE/PM), Engineering Change Orders (ECOs), and Integrated Logistics Support/Spares/Government Support Costs. Independent design and engineering estimates were made for each of the modernization elements with the exception of the Improved Cargo Hook System, which was included in the SLEP cost estimate. Therefore, a percentage of the original SLEP cost was used to approximate and separate the cost of the hook system so that cost estimates for configurations that included the SLEP but not the hook system would be more accurate.

FTA costs include material and labor for the manufacture of modernization element kits as well as the Induction, Disassembly, Inspection, Assembly and Test (IDIA&T) required integrate and manufacture the FTAs themselves. ST/STE, ST&E and ILS/Spares/Government Support Costs were determined by an expert estimate and were not adjusted for each of the alternatives. SE/PM and ECO costs were calculated by applying rates to the sum of the other cost elements with the exception of the ILS/Spares/Government Support Costs.

Production costs comprise the bulk of the procurement costs and include the labor and materials to fabricate the modernization kits for each of the elements, IDIA&T, ST/STE, ST&E, ECOs and ILS/Spares/Govt. Support costs. IDIA&T costs could not be separated into individual cost elements and therefore the same costs were allocated to all alternatives. All other production cost elements were allocated in the same manner as in the development effort.

Because some costs could not be linked to each modernization alternative, estimates for configurations with fewer modernization elements are likely inflated over what would be expected. This weakens the cost distinction between some of the alternative configurations, yet doesn't render the model valueless. Additionally, ongoing cost estimating efforts, that use analogous data from other programs such as the Army's CH-47F Improved Cargo Helicopter (ICH) Program, should yield more accurate cost estimates. However, these data were not available at the time of this writing. Additionally, the sole-source assumption and the lack of any competition inflates the project cost and fails to capture the effects of incorporating competition into the procurement.

2. Operating and Support Cost Measures

Attempting to capture the potential operating and support cost impact of various modernization configurations proved to be much more difficult than anticipated. Nonetheless, research did yield some relevant insights that modernization acquisition managers should bear in mind as they seek to develop a program to modernize the CH-53E. Additionally, investigating the operating and support cost issues demonstrated how the challenges facing program managers for major weapons systems are not easily isolated and overcome. This section will highlight some of those difficulties as well as document the approach taken to collect operating and support cost data and the rationale behind the measures actually used in LDW.

Before beginning to collect data, it was important to define the relevant costs for this study. In particular, what are the costs that can realistically be affected by a modernization effort and which costs seem to be most affected by aircraft aging? Not surprisingly, focusing on these costs excludes a great deal of the personnel and infrastructure costs that typically remain unchanged when a weapon system is modernized. Nonetheless, actually separating and isolating these costs for measurement and analysis is not as simple as it might appear. One part of the difficulty and confusion can be attributed to the budgetary language used to describe the costs of running the Department of Defense (DoD). Conceptually, O&S costs include all the costs associated with the day-to-day functioning of the military and are funded from a variety of budgetary accounts. Most of the funding for the daily operations of the Navy and Marine Corps is paid out of the Operations and Maintenance, Navy (O&MN) account. This does not include funding to pay uniformed personnel, which is paid out of the Military Personnel, Navy (MPN) account or some procurement expenditures that directly support operations that are funded out of the APN account. However, not all of the expenditures from MPN or APN are directly attributable to a given weapon system. Those costs that can be linked directly to a weapon system are the focus of this analysis because most personnel and infrastructure costs will remain unchanged under the currently proposed modernization plan. The Venn diagram below depicts the interrelation between some of these costs.

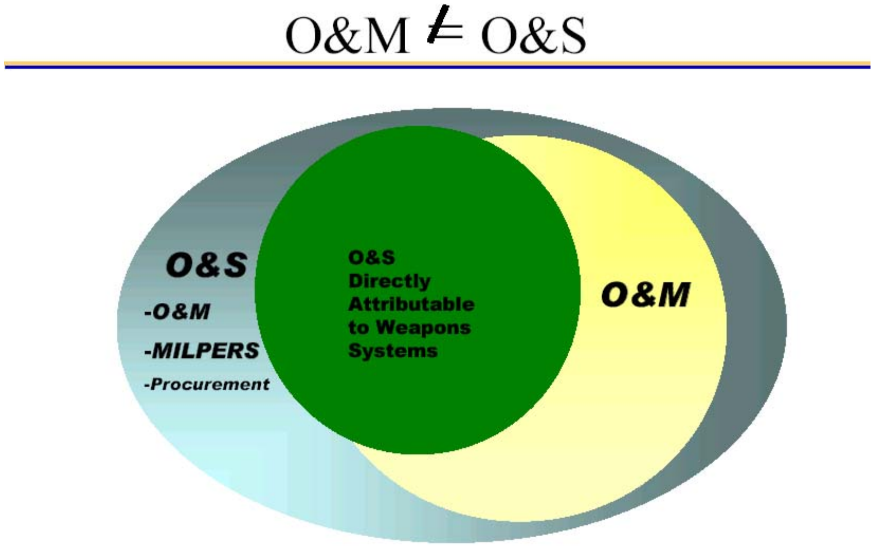

Figure 3.2 Operating and Support Cost Venn Diagram [After Ref. 21]

As Figure 3.2 suggests, because the costs to support a given weapon system draw from a variety of budgetary accounts, "cost growth" may arise in one or more of the accounts mentioned earlier. For this reason, examining macro-level expenditures in budgetary accounts fails to capture cost growth problems with individual programs. Additionally, because the Armed Forces are each budgeted a finite dollar amount for each account (O&MN, MPN, APN, etc.), rising maintenance costs necessitate reductions in other areas to meet the total expenditure limits. While this seems intuitive, a recent Congressional Budget Office study reported, "the fact that aging equipment does not appear to be driving *total* O&M spending does not rule out the possibility that the costs of operating and maintaining equipment increase with the age of that equipment (italics added)." [Ref. 22] This indicates that some officials were under the impression that the rising costs of aging systems were actually forcing the services to exceed or increase their O&M budget limits.

To facilitate the comparison and analysis of O&S costs across platforms, the Office of the Secretary of Defense (OSD) Cost Analysis Improvement Group (CAIG) has published an O&S cost element structure (See Figure 3.3 below). This structure provides a framework to capture the Total Ownership Costs associated with a given weapon system. The costs that typically receive the greatest attention are those elements that "buy" flight hours to accomplish naval aviation missions and training because these account for the greatest percentage of total ownership costs (other than personnel) and tend to be most responsive to system modernization efforts. These cost elements are funded under the Flying Hour Program (FHP) that is drawn from the O&MN account.

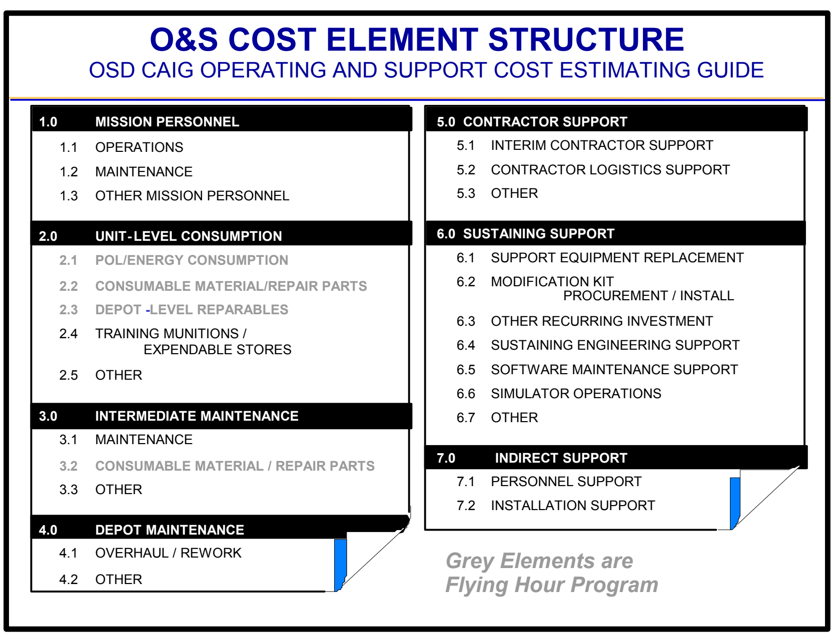

Figure 3.3 CAIG O&S Cost Element Structure [After Ref. 23]

In the aggregate, FHP costs accounted for approximately 38% of the nine billion dollars expended in fiscal year 1999 to operate and support naval aviation [Ref. 21]. The most recent O&S cost study of the CH-53E found a similar distribution of costs. Table 3.3 shows the percentage distribution of O&S costs according to the CAIG cost element structure. Notice that element 2.3 Depot Level Repairables accounted for the greatest percentage of O&S costs.

Table 3.3 CH-53E O&S Cost Driver Percentages [After Ref. 24]

CH-53E			
CES	**FY2000 AIR 4.2.5 TOC/O&S Cost Element Structure Cost Driver Percentages & $/Flight Hour**	**% of Total (SQN)**	**$/Flight Hour**
1.0	**MISSION PERSONNEL**	**28.2%**	**4,058**
1.1	OPERATIONS	6.1%	880
1.2	MAINTENANCE	16.9%	2,428
1.3	OTHER MISSION PERSONNEL	5.2%	751
2.0	**UNIT-LEVEL CONSUMPTION**	**23.7%**	**3,402**
2.1	POL/ENERGY CONSUMPTION	1.7%	251
2.2	CONSUMABLE MATERIAL/REPAIR PARTS	4.5%	646
2.3	DEPOT LEVEL REPAIRABLES	17.2%	2,471
2.4	TRAINING MUNITIONS/EXPENDABLE STORES	0.0%	0
2.5	OTHER	0.2%	34
3.0	**INTERMEDIATE MAINTENANCE**	**8.1%**	**1,163**
3.1	MAINTENANCE	4.4%	634
3.2	CONSUMABLE MATERIAL/REPAIR PARTS	3.7%	529
3.3	OTHER	0.0%	0
4.0	**DEPOT**	**13.6%**	**1,952**
4.1	OVERHAUL / REWORK	9.2%	1,325
4.2	ENGINE REPAIR	2.2%	315
4.3	OTHER	2.2%	312
5.0	**CONTRACTOR SUPPORT**	**0.0%**	**0**
5.1	INTERIM CONTRACTOR SUPPORT	0.0%	0
5.2	CONTRACTOR LOGISTICS SUPPORT	0.0%	0
5.3	OTHER	0.0%	0
6.0	**SUSTAINING SUPPORT**	**9.2%**	**1,328**
6.1	SUPPORT EQUIPMENT REPLACEMENT	0.1%	7
6.2	MOD KIT PROCUREMENT / INSTALLATION	8.3%	1,187
6.3	OTHER RECURRING INVESTMENT	0.0%	0
6.4	SUSTAINING ENGINEERING SUPPORT	0.6%	86
6.5	SOFTWARE MAINTENANCE SUPPORT	0.1%	18
6.6	SIMULATOR OPERATIONS	0.0%	6
6.7	OTHER	0.2%	24
7.0	**INDIRECT SUPPORT**	**17.2%**	**2,475**
7.1	PERSONNEL SUPPORT	10.5%	1,504
7.2	INSTALLATION SUPPORT	6.8%	971
	Total	**100.0%**	**$14,378**

Several databases are used to collect data and develop these cost percentages. FY 2000 costs reflect averages of data collected between 1996 and 1998. According to the

FY2000 CH-53E Program Operating and Support Cost Analysis published by NAVAIR, Aviation Depot Level Repairables (AVDLRs) accounted for $2,471/flight hour of the total O&S cost of $14,378/flight hour [Ref. 24]. Yet, because these data are based upon averages from earlier years, then inflated to FY00$, it fails to capture more recent trends, which would alert decision-makers of a potential problem. While it seems clear that attacking AVDLR cost growth represents the "low hanging fruit" in the fight to reduce O&S costs for an aging system, identifying a course of action to pluck the "low hanging fruit" can be confounded by accounting practices that mask cost trends. For example, a Cost Recovery Rate (CRR) is applied to the "price" charged operational units for their AVDLRs. This rate is adjusted annually to balance the Navy Working Capital Fund (NWCF), accounting for changes in supply system and repair depot operations costs, and does not follow any predictable trends. Figure 3.4 below depicts the relationship between total AVDLR cost per flight hour and the CRR deflated AVDLR cost per flight hour. The CRR rate applied to CH-53E AVDLR costs is also depicted.

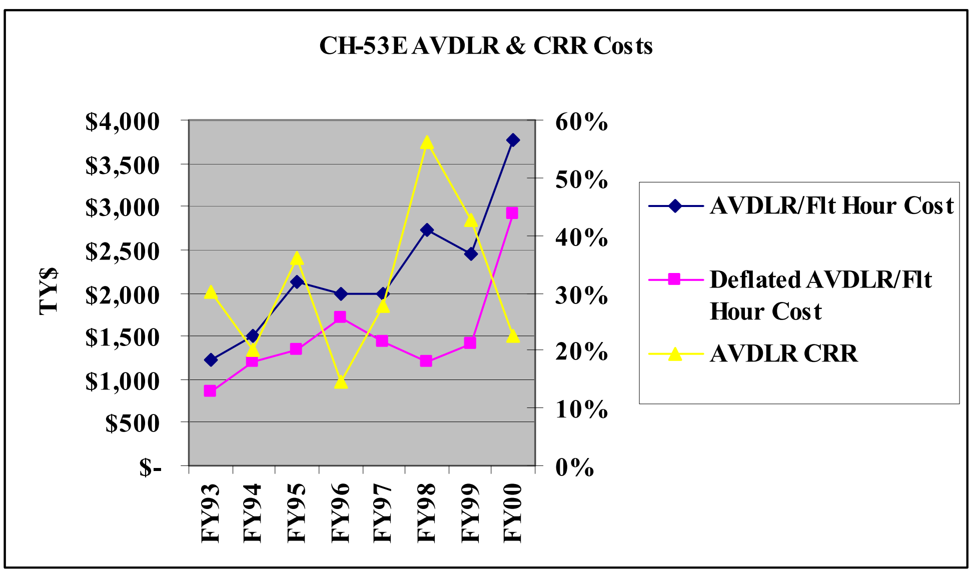

Figure 3.4 FY93-FY00 CH-53E AVDLR & CRR Costs [After Ref. 25 & 26]

Clearly AVDLR costs are rising; nonetheless this chart demonstrates that there are significant costs associated with AVDLRs that are beyond the control of the program office. For this reason, acquisition managers should realize the limited impact modernization efforts might have on aging aircraft. This is not to say that attempts to reduce O&S costs through modernization are fruitless, only that the magnitude and complexity of the costs allocated to AVDLR costs might negate or at least dampen the potential reductions in O&S costs.

Armed with a knowledge of how O&S costs, and in particular AVDLR costs, are allocated to a program, attention was then focused on discovering what the potential O&S cost impacts of the proposed modernization elements might be. To obtain this level of visibility, AVDLR cost information was obtained for components affected by the proposed modernization. Costs were obtained by querying the Logistics Management Decision Support System (LMDSS). LMDSS was developed to facilitate continuous action by the Naval Air Systems Command (NAVAIR) and Naval Inventory Control Point (NAVICP) Philadelphia logistics management teams to measurably reduce the life cycle support costs of aviation systems while protecting readiness [Ref. 27]. The LMDSS application is capable of retrieving a variety of data for logistics managers. One function, called "Candidate Identification," allows the user to query the database and construct reliability, supportability, and cost (R/S/C) summary matrices for particular airframes, sub-assemblies, components, or individual parts. The granularity visible in the matrix is determined by the number of digits in the Work Unit Codes (WUC) specified for the item/system being queried. WUC detail ranges from two-digits, which corresponds to major subsystems of the aircraft, to seven-digits that represent individual piece-parts. The matrix provides summary AVDLR, Aviation Fleet Maintenance (AFM) and Direct Maintenance Man Hour Dollars (DMMH$) data as well as total support costs. LMDSS calculates total support costs by summing the AVDLR, AFM and DMMH$ cost categories (See Appendix D).

The Sikorsky operating and support cost baselines presented below were based on data obtained from LMDSS. Sikorsky presented these data to Marine aviation leaders in response to their request for information on projected options and the potential cost impacts of modernization. Due to proprietary restrictions, the author was not allowed access to the source data used to calculate the O&S cost savings. Without this information it would be impossible to critically evaluate the validity of the Sikorsky projections. It is important to note that the "O&S Savings for Returning Parts" represents a one-time credit from the supply system for the turn-in of Ready For Issue (RFI) components that would be replaced under the proposed modernization and therefore should not be considered a flight hour recurring O&S cost savings.

Table 3.4 Sikorsky ROM Estimates for O&S Costs Per Flight Hour [After Ref. 28]

Modernization Element	**Current O&S Cost**	**Actual O&S Savings**	**O&S Savings for Returning Parts**	**Total O&S Savings**	**New O&S Cost**
Engines	$447.00	-$155.00	-$103.00	-$258.00	$292.00
Blade	$154.00	-$125.50	-$157.50	-$283.00	$28.50
Cockpit	$145.00	-$18.23	-$22.77	-$41.00	$126.77
Rotorhead	$390.00	-$234.43	-$117.57	-$352.00	$155.57
Cargo Hook Sys	$73.00	-$11.00	-$7.00	-$18.00	$62.00
SLEP (Wiring)	$34.00	-$17.00	N/A	-$17.00	$17.00
SLEP (D/S/Bearings)	$56.00	-$10.00		-$10.00	$46.00
SLEP (Airframe)	$444.00		N/A		$83.00
SLEP (Airframe)		-$250.00		-$250.00	
SLEP (Airframe)		-$111.00		-$111.00	
TOTAL	**$1,743.00**	**-$932.16**	**-$407.84**	**-$1,340.00**	**$810.84**

While it was not possible to quantify the O&S cost impact of modernization with a reasonable degree of accuracy, it was possible to draw some important conclusions. Only approximately $1,743 in O&S Costs, out of a total of $14,378, will be affected by any modernization efforts. The most recent data indicates that aging components along with growing obsolescence is causing AVDLR costs to grow at a more rapid rate. Nonetheless, Sikorsky's aggressive cost savings estimate yields only a $27M/year savings and fails to account for many costs allocated by the CRR being unavoidable and that they will not be affected by component improvements. With these considerations taken into account, a conservative cost savings estimate of $10M-$15M/year seems more prudent.

In the absence of quantifiable O&S cost data, a categorical proxy was used indicating whether O&S costs would rise, decline or remain the same. The categorical descriptors used for each modernization configuration were based on the author's subjective assessment of likely O&S cost outcomes given current cost trends and the magnitude and complexity of the modernization elements involved. Three of the components (blades, rotor head, and engines) targeted by the modernization program made the AVDLR top 100 cost driver list maintained in the Aviation Maintenance and Supply Readiness (AMSR) database. This indicates that the modernization effort is indeed proactively addressing critical areas of O&S cost growth.

The current model fails to quantify the O&S cost impact; as more exacting design and testing information becomes available it should be incorporated into the model. However, any proposed O&S cost savings presented in the future and subsequently incorporated in to this model should include their reduced impact due to unavoidable allocated costs, such as the CRR. Additionally, O&S cost savings derived from improved Mean Time Between Failures (MTBFs), Time Between Overhauls (TBOs) and on-condition maintenance initiatives must be validated by testing or simulation.

3. Operational Effectiveness Measures

As mentioned earlier, operational effectiveness measures included both objective and subjective measures. Objective measures consisted of a combat radius range measurement as well as a payload measurement. Individual configuration measures were calculated based performance parameters and conditions depicted in Figure 2.6, CH-53E Performance Capabilities (New Engines and Blades) [Ref. 11]. The common units measurement of both payload and range were adjusted to reflect the user preferences outlined in the draft Operational Requirements Document (ORD) [Ref. 29].

Subjective measures were gathered through a survey distributed to five CH-53E pilots/instructors from Marine Aviation Weapons and Tactics Squadron One (MAWTS-1). A copy of the survey is included in Appendix E. The survey asked the instructors to evaluate each of the modernization configurations and assign a categorical descriptor (See Table 3.5) of expected performance under each METL. The evaluators were instructed that when assigning categorical descriptors, to take into account all factors that might improve the aircraft's ability to prosecute its mission. This liberal interpretation of enhanced performance included, but was not limited to, such topics as the evaluator's assessment of any potential improvements in readiness. However, evaluators were instructed <u>not</u> to include in their assessment any perceived cost reductions or increases, as these impacts would be captured in the model's cost measures. Once categorical descriptors had been assigned to each modernization configuration/ METL combination, the evaluators were asked to prioritize METLs, by assigning percentage weights to each of the METLs (such that the percentages summed to 100%). Weights were assigned according to the evaluators' assessment of which METLs would constitute the most critical mission areas from the present until 2025. Both weights and categorical descriptors were "averaged" to arrive at a composite measure that was then input into the LDW model.

Table 3.5 CH-53E Operational Effectiveness Categorical Descriptors

A. Significantly enhances current capability	
	Performance improvement is likely to meet projected requirements until 2025
B. Enhances current capability	
	Performance will be improved but will likely require further improvements/technology refreshment before system retirement
C. Doesn't alter current capability	
	Self-explanatory
D. Provides for Limited capability	
	System will still meet some requirements but will be unable to meet the full range of projected requirements until 2025
E. Lack of capability is a performance liability	
	Performance shortfall will likely result in the inability of the Marine Corps to successfully prosecute the sort of missions anticipated until 2025

More objective measures would have increased the robustness of the model. However, the critical design information necessary to generate quantitative measures of effectiveness was not available. As such design information becomes available, Key Performance Parameters (KPPs) should be incorporated into the model as additional effectiveness measures. Readiness rate projections would also help to capture the non-cost benefits of greater reliability and supportability. While subjective measures, such as those obtained from the survey, are less desirable than objective measures, they do provide an accurate means of capturing end user desires and priorities. Because defense procurement decisions and success are based on building coalitions of support, it is critical to incorporate effectiveness measures that capture various stakeholders' views.

For this reason, future iterations of the model should continue to include subjective expert assessments as part of the effectiveness measure.

D. COST AND OPERATIONAL EFFECTIVENESS ANALYSIS

1. Weighting

In order to develop a consensus on how sub-goals should be weighted, program management personnel were interviewed and asked which sub-goals they felt were most critical to programmatic success. Programmatic success was defined as meeting cost and schedule parameters at the various milestone decision points and most importantly, delivering an effective weapon system to the user on time. All managers interviewed agreed that the weighting or prioritization of sub-goals would wax and wane with program progress. For example, while development costs are a relatively small portion of system total ownership costs, there is a much greater level of uncertainty and therefore scrutiny associated with them. Programs that demonstrate poor cost control in the development phase are more likely to be "killed."

Because this model was constructed as an ongoing decision aid to acquisition managers, each of the sub-goals was given equal weight, with the thinking that as the situation dictated, weights could be adjusted to account for changing priorities. Second tier sub-goals and measures were also given equal weight with the exception of the subjective operational effectiveness measures, which were weighted according to the average percentage weights assessed by the MAWTS-1 evaluators. Using the "smarter method" of assessment, an equal weighting for the various sub-goals and measures was achieved by ranking them all as number one priorities.

One of the most powerful tools provided by LDW is the ability to graphically depict various elements of the decision process. This provides insight into how altering circumstances may affect the recommended outcome. Figure 3.5 is a graphical depiction of the relative weights assigned to each member (sub-goal and measure). When viewing this graphic in LDW, the user is able to manipulate the weights and immediately see how that affects the recommended outcome. This sort of sensitivity analysis and the insight it provides into the CH-53E modernization will be discussed in the next section.

Member	Weight
Max Msn Performance (Subjective)	33.3
Max Msn Performance (Objective)	33.3
Minimize TOC	33.3
Minimize Procurement Cost	16.7
I. Payload 3H Scenario	16.7
J. Range 3H Scenario	16.7
M. O&S Costs	16.7
H. Night/IMC METL	10.3
L. RDT&E Cost	8.3
K. APN Cost	8.3
A. Assault METL	6.0
B. Raid METL	4.3
G. Ship Ops METL	3.7
F. NEO METL	3.0
C. TRAP METL	2.7
D. MEDEVAC METL	1.7
E. Spec Ops METL	1.7

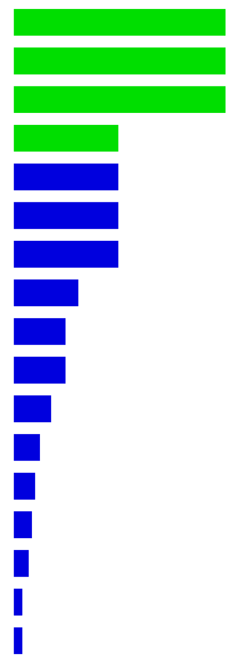

Figure 3.5 LDW Sub-goal and Measure Relative Weights

2. Sensitivity Analysis

Given the data provided in the model and the weights assigned to the various members within the model, LDW ranks the alternatives under a specified goal. In this instance, we are most concerned about the overall goal of choosing the best modernization configuration. However, it is also important to consider those elements that are not captured by the model and how their inclusion might affect the overall recommendation. As discussed earlier in this chapter, there are three general areas that could have significant impact on the course of action recommended by the model: 1) Cost

Uncertainty, both with the costs included and those, such as O&S costs, that are not captured in the current model; 2) Performance Uncertainty, due to the subjective assessments used, as well as the early estimates of performance levels that were used to develop the objective operational effectiveness measures; 3) Omitted Measures, this includes measure elements that could not be captured anywhere in the model as it is presently constructed, such as the benefits of commonality or the non-cost impacts of schedule changes. All of these elements may be incorporated into the model at a later time but should be considered in using the current model as a decision aid. Figure 3.6 below is a graphical depiction of the ranked alternatives under the overall goal and their corresponding utilities. The tick marks to the right end of each bar represent the range of uncertainty associated with each utility, and are derived from the probabilistic distributions used to generate the procurement cost estimates. The LDW model does not capture uncertainties associated with measures not having probabilistic distributions, such as those using categorical measures.

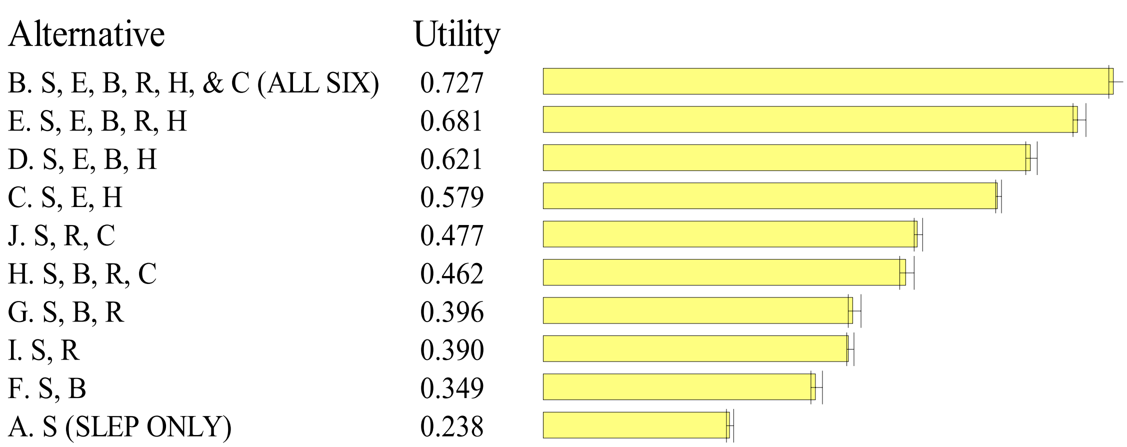

Figure 3.6 LDW Best Configuration Goal Alternative Ranking with Uncertainties

Not surprisingly, the complete modernization configuration received the highest overall utility. However, the order of the ranking does provide some insight. In particular, the configurations with the modernized rotor head as one of the major elements failed to receive higher utility scores. This is most likely due to the greater developmental costs associated with that element, combined with limited performance improvements. The greatest benefit of the rotor head is likely to be greater reliability and/or reduced O&S costs. Nonetheless, because the development effort of this element is more risky and costly, if this model were used it would be the first element removed if funding levels were reduced. This is also demonstrates how the incentives for program managers drive decisions that favor short-term savings with certainty over long-term savings with uncertainty.

Using the LDW "Dynamic Sensitivity" tool, weights can be adjusted to see how they affect the recommended configuration. For example, since the O&S cost estimate was based solely on the author's assessment, it seemed prudent to see how removing this element would affect the ranking. Surprisingly, it had little affect; the full modernization configuration was still ranked the highest, although not by as large of a margin as it was in the original model. Adjusting the weights of various sub-goals and measures did little to alter the overall ranking. While this suggests that the complete modernization configuration is the best choice, it also highlights how some measures still need to be incorporated into the model. In particular, the addition of quantitative data that can be assigned a probabilistic distribution will likely yield more insightful results.

Because a linear relationship was assumed between costs and utility, there is an implicit assumption that decision-makers are risk-neutral across the spectrum of cost outcomes. Clearly this is unlikely. However, in order to determine how decision makers might behave, information on likely funding levels is required. Once program managers know the rough amount of funding that is available and their relative standing in relation to other programs competing for funding, they can identify funding break points that alter decision-maker valuation of costs and may change alternative rankings. Additionally, once actual costs begin to be incurred, the model can be modified slightly to incorporate Earned Value Management System (EVMS) data and used as an ongoing decision tool for acquisition managers.

The importance of matching resources and freezing requirements early in the process cannot be overstated. The current model was constructed around several key assumptions that, if violated, could dramatically alter program success. Primary in those assumptions are the goals of the program and the alternatives available to meet those goals. Obtaining funding levels that support the program timeline is critical to success. Requirements "creep," where the call for greater capability results in continually adjusting program goals, poses the greatest threat to program success. There are several elements that were not included in this model because debate continued concerning their relative merits. A final determination must be made prior to program initiation and user representatives must understand the complications that adding requirements creates. In order to limit their call for such modifications, the user community must understand the financial and political realities constraining the program. Otherwise the goals, and thus the requirements of the program, will continue to be a source of debate.

As mentioned throughout this chapter, some measures were not captured in the current model but should be incorporated into later iterations, including: schedule metrics, quantitative O&S measures validated by testing or simulation (without some sort of validation they should be omitted as these sort of things are easy to promise and hard to deliver), and objective operational effectiveness measures linked to KPPs. Each of these metrics should use probabilistic distributions to capture any uncertainty in measure levels. This allows greater visibility into overall outcomes when the alternatives are ranked. Nonetheless, as a first step, this model provides acquisition managers with a powerful tool for crafting and understanding their acquisition strategy, which will be the subject of the subsequent chapter.

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IV. ACQUISITION STRATEGY AND CONTRACTING PLAN ANALYSIS

A. INTRODUCTION

This chapter provides a framework, description, discussion and analysis of some of the issues and factors that must be considered in constructing an acquisition strategy and contracting plan for CH-53E modernization.

Based on results of the preliminary cost effectiveness analysis discussed in Chapter III, a complete six-point modernization effort provides the scope of work to be encompassed by the acquisition strategy. The CH-53E modernization acquisition can be divided into the three phases outlined in the most recent revision of the DoD 5000 series (see Figure 4.1): Concept and Technology Development (C&TD), System Development and Demonstration (SD&D), and Production and Deployment (P&D).

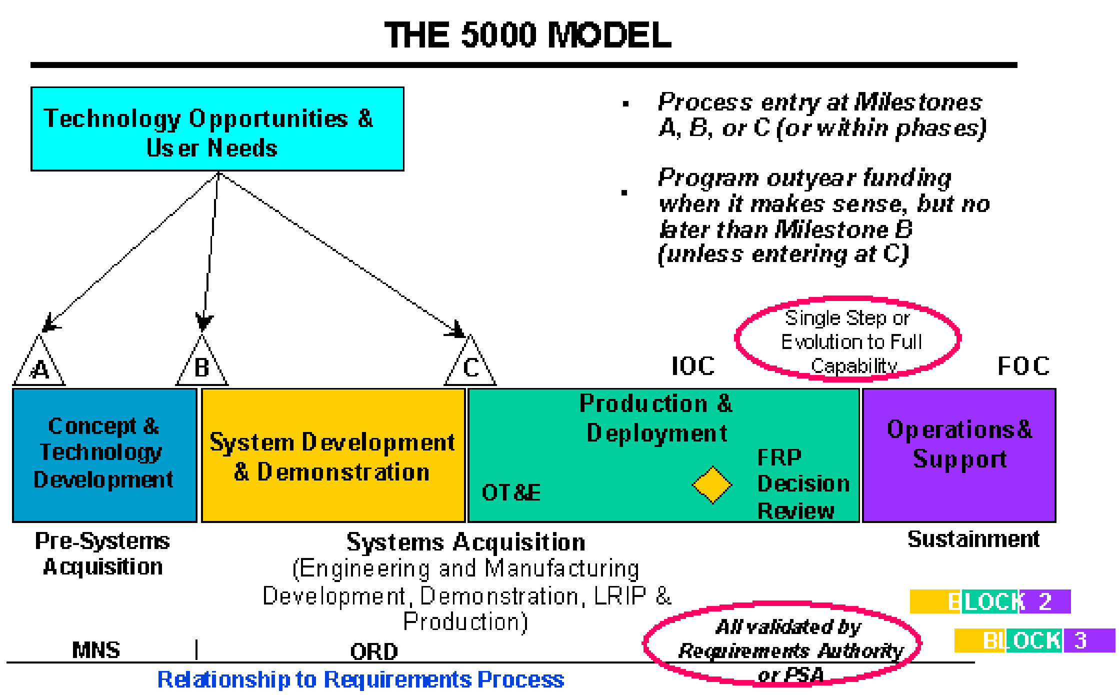

Figure 4.1 Defense Acquisition Management Framework [Ref. 30]

For the CH-53E modernization effort C&TD involves business case analyses, proof of principle evaluations, market research and trade studies to evaluate business and technical options. SD&D involves actual engineering development and integration of the planned modernization elements to ensure the architecture principles that form the foundation of the program are sound. Finally, P&D involves scheduling and actual production to modernize of the CH-53E fleet.

To facilitate analysis and discussion, the acquisition was further partitioned into three groups based upon the nature of work required. The first is the engine and engine logistics support portion. The second is the cockpit portion. The last constitutes all remaining modernization elements, including the SLEP, rotor head, improved cargo handling system and blades. Each of these portions corresponds with three, potentially different, suppliers. For this reason, each of these groupings will be addressed in the subsequent sections of this chapter. Because of the diverse and complex nature of work to be performed along with the possibility of three independent suppliers, crafting a strategy that integrates these different work elements is essential and will be the guiding focus of this chapter.

It is important to note that the acquisition strategy discussion and analysis below does not capture <u>all</u> the potential issues that must be considered prior to program initiation. However, it does outline the salient elements that require the most attention and some potential means for dealing with them.

B. CH-53E MODERNIZATION ACQUISITION ENVIRONMENT

Acquisition strategies primarily serve as a contract between the program manager and the leadership within the Department of Defense. They chart a course for the procurement so that leaders can track and measure program performance. Yet, there are many other stakeholders, both outside and inside DoD, that must be satiated when formulating a successful acquisition strategy. The strategy itself becomes a written portrait of coalitions made to meet a variety of competing interests. For this reason, it is important to survey the acquisition landscape to find the pitfalls that have befallen previous programs. Armed with this information, acquisition managers can craft a strategy that is tailored to the specific procurement as well as resilient enough to survive the gauntlet of bureaucratic and political review. This section will provide a snapshot of some relevant programs and issues currently being debated within the acquisition community that will likely impact the form and substance of a CH-53E modernization acquisition strategy.

While DoD's annual weapon systems investment has increased from about $90 billion three years ago to approximately $100 billion for fiscal year 2001 [Ref. 31], the competition for funding grows fiercer as current weapon systems age and the cost for new systems escalates. A quick look at the status of Marine Corps aviation platforms provides a clear picture of the level of competition. Every tactical aviation platform in the Marine Corps has a program in place to either replace or upgrade the current platform. This places aviation investment dollars at a premium and is confounded by the problems recently experienced by some of these programs, such as the V-22 Osprey.

Another challenge is presented by the failures and problems that have plagued recent modernization and upgrade efforts. For example, after a considerable development effort, the Navy H-60 Seahawk program realized that modernizing their older aircraft would only slightly lower unit cost and probably lower readiness rates due to the reinstallation of refurbished dynamic components on a new airframe [Ref. 32]. Similarly, the plan to remanufacture day attack variants of the AV-8B Harrier to provide a night radar attack capability received significant scrutiny from the General Accounting Office (GAO). As in the case of the H-60, the decision to remanufacture existing airframes added significant risk to the program because it relied upon "best case" performances from government depots to provide critical components to the contractor. If the depots failed to perform perfectly, there existed a significant possibility for cost growth and schedule slippage due to government-caused delays in production [Ref. 33].

Another modernization effort, the H-1 Upgrade program, has experienced considerable cost growth during their development effort. The original development contract was for $567 million; however, recent indications from the contractor suggest that the total cost for the development effort will likely approach $1 billion [Ref. 34]. The cost growth in the H-1 Upgrade development effort highlights yet another problem often identified in GAO reports on government acquisition inefficiency. They have found that, "the desire of program sponsors to keep cost estimates as low as possible and to present attractive milestone schedules encourages the use of unreasonable assumptions about the pace and magnitude of the technical effort, material costs, production rates, savings from competition, and other factors [Ref. 35]." The institutional tendency to project optimistic outcomes as a means of protecting program funding routinely compromises some aspect of cost, schedule or performance objectives. Yet program managers are often faced with a quandary; realistic statements of program costs and schedules would prevent a new program from being initiated. This problem is created by a failure to communicate fiscal and political realities to the requirements generation community.

Because of the early stage of the CH-53E modernization effort, now is the time to rectify and clarify these issues. The ORD remains in draft form and the requirements community has not reached consensus on all the elements modernization might entail. As a recent GAO report highlighted, successfully matching developer resources with user expectations prior to product development is a key factor in determining whether cost, performance and schedule objectives are achieved. Table 4.1 illustrates how various complex products in both the commercial and military sectors demonstrate this principle.

Table 4.1 Matching of Expectations to Resources and Product Development Outcomes [After Ref. 31]

Programs	Expectations and resources adequately matched before launch	Product development cost growth	Product development schedule delays
Caterpillar 797 mining truck	Yes	5 percent	0 percent
NASA FUSE	Yes	20 percent	0 percent
Radio Frequency Countermeasures system	No	197 percent	23 percent
Crusader artillery vehicle	No	55 percent	26 percent
Comanche helicopter	No	127 percent	119 percent
Brilliant Anti-armor Submunition	No	99 percent	46 percent
Bombardier BRJ-X[a]	Yes	On target	On target
Tactical Unmanned Aerial Vehicle[a]	Yes	On target	On target
Global Hawk Unmanned Vehicle[a]	Yes	On target	On target

[a] Specific cost and schedule data for the Tactical Unmanned Aerial Vehicle, Global Hawk Unmanned Aerial Vehicle, and Bombardier BRJ-X Regional jet were not included in the table because they had not been in the product development phase long enough to report actual cost and schedule variances. However, these programs had already avoided some of the problems experienced by the programs that did not match expectations and resources before launch. These programs were on target for meeting their objectives.

As Table 4.1 illustrates, now is the time for CH-53E program management personnel to communicate the fiscal and political constraints to the user community to develop and “freeze” requirements that are achievable, given the current resource environment. If requirements are allowed to fluctuate during development, it will be difficult or impossible to ensure the resources necessary are available to meet those requirements.

Finally, because the CH-53E is an aging aircraft, it is natural and logical to assume that any modernization effort would seek to address areas that have experienced cost growth as the airframe has aged. Yet, design improvements or replacing components that cause operating and support cost growth, such as the rotor head, provide little performance enhancement and therefore tend to be a lower priority with the user. However, failure to address such components now could lead to exponential cost growth as components reach unprecedented ages.

All of these issues contribute to the bureaucratic and political debate that has become an unavoidable part of Acquisition Category 1 (ACAT 1) program initiations. While it is impossible to detail all of the political hurdles that the CH-53E modernization effort might encounter, one area that will undoubtedly generate attention is the suggestion to use Contractor Logistic Support (CLS), versus using the military depots, for engine intermediate and depot level maintenance. That issue and some steps that can be taken to overcome its opposition will be discussed in the business and contracting strategy section of this chapter. For this and many other reasons, program managers must continually survey the acquisition landscape and ask themselves what they are doing to ensure their programs don't fall victim to the problems identified above. The subsequent sections are intended to chart a course for success for the CH-53E modernization effort in light of all these and many other challenges currently facing acquisition managers involved in complex weapon system programs.

C. REQUIREMENTS, PROGRAM STRUCTURE AND ACQUISITION APPROACH

1. Requirements

Because the details of the relevant source documents, such as the ORD, applicable Capstone Requirements Documents (CRDs), and Acquisition Program Baseline (APB) are yet to be definitized, an opportunity exists for both the user and program management personnel. Now, prior to program initiation, is the time for both parties to work to match requirements and resources. As Figure 4.2 depicts, this process relies on power parity between the two parties; without it, one party can compel the other to continue toward program initiation prior to establishing a course of action that will achieve program objectives. Additionally, by working together at this early stage, and by engaging contractors in the systems engineering analysis of the requirement, technical and cost obstacles can be identified and avoided prior to the expenditure of significant funds.

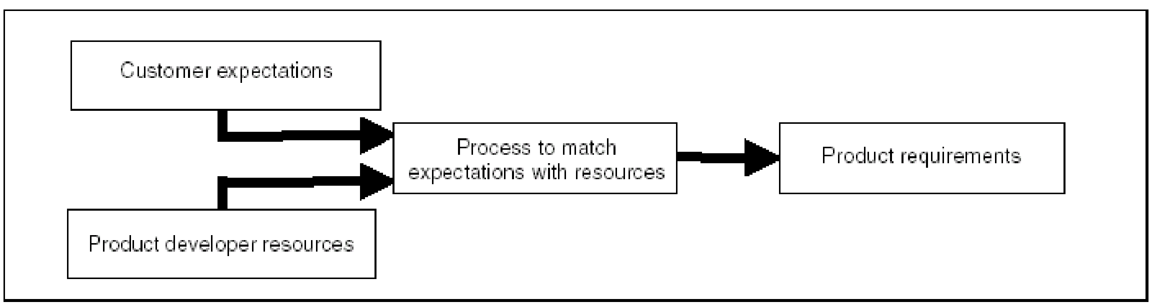

Figure 4.2 The Requirements Process [After Ref. 31]

While the basic requirement stems from the need to provide the Marine Corps a heavy lift capability until 2025, the specifics require greater lift and range capabilities, the ability to communicate and operate in a larger battle space, a reduction in operating and support costs and commensurately improved readiness rates. Specific cost, schedule and performance targets should be identified and agreed upon as feasible by the user community, program manager and prospective contractors prior to program initiation. These capabilities are expected through a single-step upgrade, yet should also incorporate open systems architecture in some areas to facilitate later improvements. Specifically, the cockpit and its components should allow for software and hardware evolutionary changes as necessary and incorporate the overarching goals specified in the Common Avionics Master Plan (CAMP).

Due to the fluidity of the requirements, this acquisition strategy will provide guidelines and considerations based on the generic requirements available at this time. The active participation and input of potential contractors in developing the requirements is essential to program success. The ORD should be sufficiently defined in concert with program initiation. As part of the requirements process, concurrent analysis should evaluate the impact of modernization on dynamic components, measured against the cost of new procurement, to determine if modernization is the most cost effective means of achieving the specified requirements.

2. Program Structure

Because initiating concerted efforts toward CH-53E modernization depends upon future funding, the notional program structure will likely change as the program evolves. The actual time that will elapse between various phases will largely depend upon the trade studies, requirements analyses and funding determinations during the C&TD phase. Figure 4.3 depicts the basic program structure, to including anticipated contract vehicles for the various program phases and efforts. Subsequent figures will provide more detailed information for each phase of the acquisition. At the In Progress Review (IPR) in the SD&D phase, enough cost and testing information should be available to confirm that modernization is still the most cost effective means of providing the Marine Corps an adequate heavy lift capability through 2025.

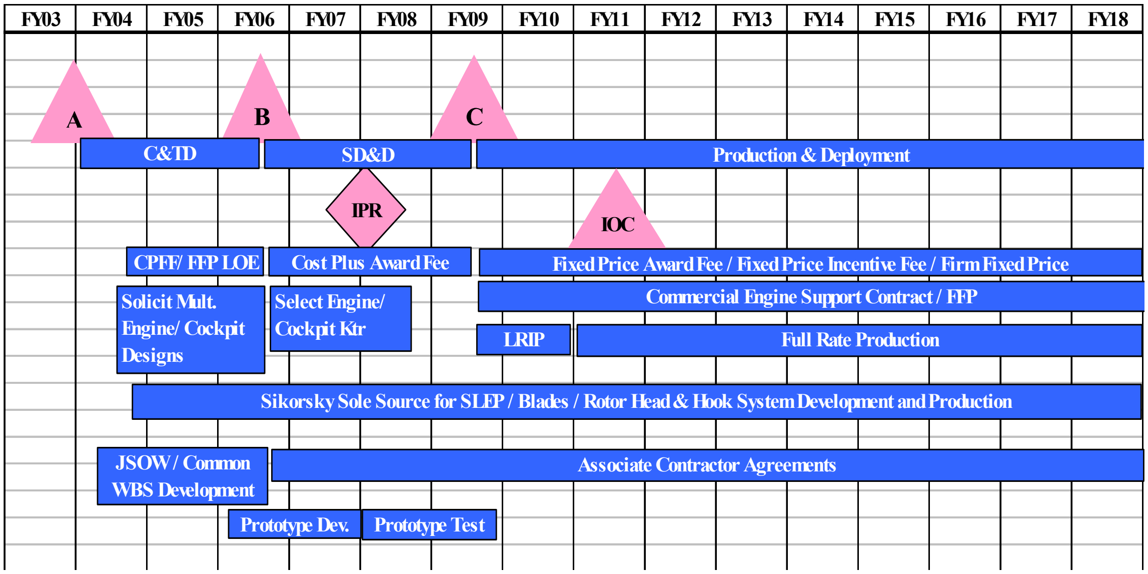

Figure 4.3 Notional CH-53E Modernization Program Structure

Figure 4.4 depicts the planned entry of the CH-53E modernization effort into the Defense Acquisition Management Framework as outlined in the DoD 5000 series of instructions and directives. Additionally, Figure 4.4 identifies the purposes of the work effort, major program events, entrance criteria and desired outcomes of this phase as well as the key parties involved in each activity. This phase primarily clarifies the modernized CH-53E requirement and ensures that the industrial capability to produce such an aircraft exists, given the projected resources. Probably the most difficult and most important issue to be resolved in this phase is striking the correct balance between increased performance while ameliorating the effects of aging and the attendant O&S cost growth. The user community will undoubtedly be less concerned with O&S cost growth and more concerned with increased performance capabilities. However, they must be persuaded that a program that can demonstrate improved maintainability and reliability through focused modernization of selected problematic components becomes much more politically and fiscally resilient. Nonetheless, MTBF improvements must be validated by testing and simulation before being accepted and used as a rationale for reduced O&S costs.

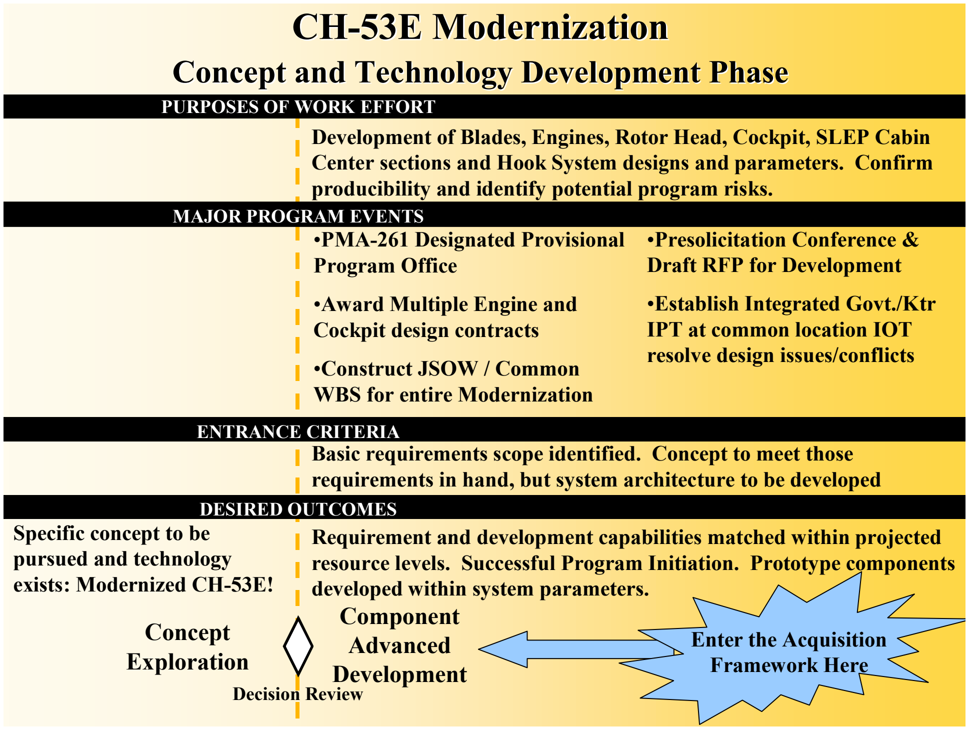

Figure 4.4 CH-53E Modernization Concept and Technology Development Phase

The work performed in the C&TD phase is very critical because user requirements, program office resources and contractor capabilities must be synthesized into an accomplishable common Work Breakdown Structure (WBS). The Integrated Product Team (IPT) established in this phase will become the focal point of the entire program effort. Contractor and industry input is essential to establish reasonable performance parameters that meet user expectations. Additionally, functional area experts, such as the NAVAIR Aging Aircraft IPT and the Combat Electronics Program Office (PMA-209), should be included in solidifying requirements and developing system solutions [Ref. 36]. With the exception of the engine and cockpit, Sikorsky will be a sole source-supplier for development and production because they have the proprietary design information necessary to develop a secondary source or compete this requirement. Attempting to develop or utilize another source would be extremely difficult and increase program risk to unacceptable levels.

A formal CH-53E modernization program office will be established at the outset of the SD&D phase; most likely this new office will be an outgrowth of PMA-261, the current H-53 program office. Figure 4.5 depicts the purposes of the work effort, major program events, entrance criteria and desired outcomes of this phase.

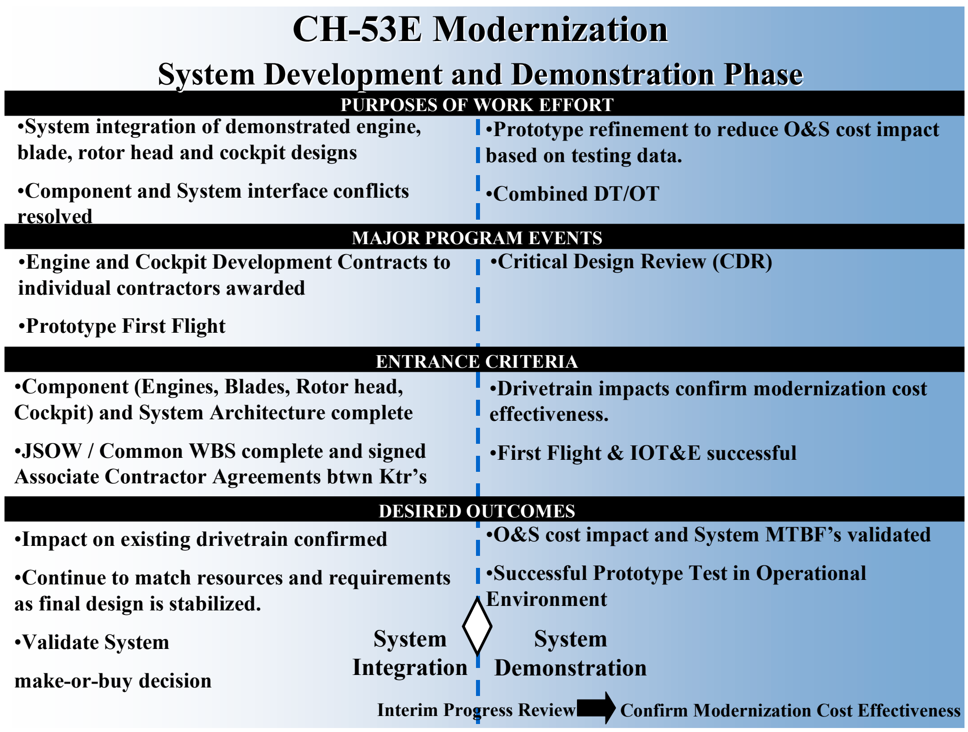

Figure 4.5 CH-53E Modernization System Development and Demonstration Phase

The SD&D phase will begin by selecting and awarding the engine and cockpit contractors based on a competitively negotiated source selection. Associate Contractor Agreements (ACAs) and an award fee incentive arrangement will ensure contractor efforts are coordinated, working to achieve IPT designated program objectives, and that any conflicts are resolved quickly. Because most modernization elements utilize existing technologies, this phase will be used to confirm the capability to integrate various modernization elements and reduce programmatic technical, cost and schedule risks.

The program IPT will continue to ensure that design changes keep program costs within resource levels as well as guaranteeing that performance remains within the user community's expectations. Any modifications to system requirements should be minor. Any major changes require program review and cost effectiveness should be reevaluated based upon performance and cost changes. All contractors will be required to use an Earned Value Management System (EVMS) to provide the IPT with a complete picture of program progression, to help identify and resolve any obstacles.

The In Progress Review (IPR) will serve as a system "make-or-buy" review, where an economic analysis of the modernization costs, including O&S cost impacts, are compared with the costs of procuring new aircraft to validate modernization cost effectiveness. Specifically, the ability of the existing drivetrain (transmissions and drive shafts) to withstand more powerful engines, rotor head and blades must be validated at the IPR.

The detailed activities for the P&D phase will be determined largely by the outcomes of previous phases. This phase consists primarily of testing and validating work performed in earlier phases. Closely monitoring contractor EVMS systems is critical in this phase as schedule slippage could have dramatic effects on the fleet's ability to maintain operational readiness. Figure 4.6 shows the critical events and issues occurring in this phase.

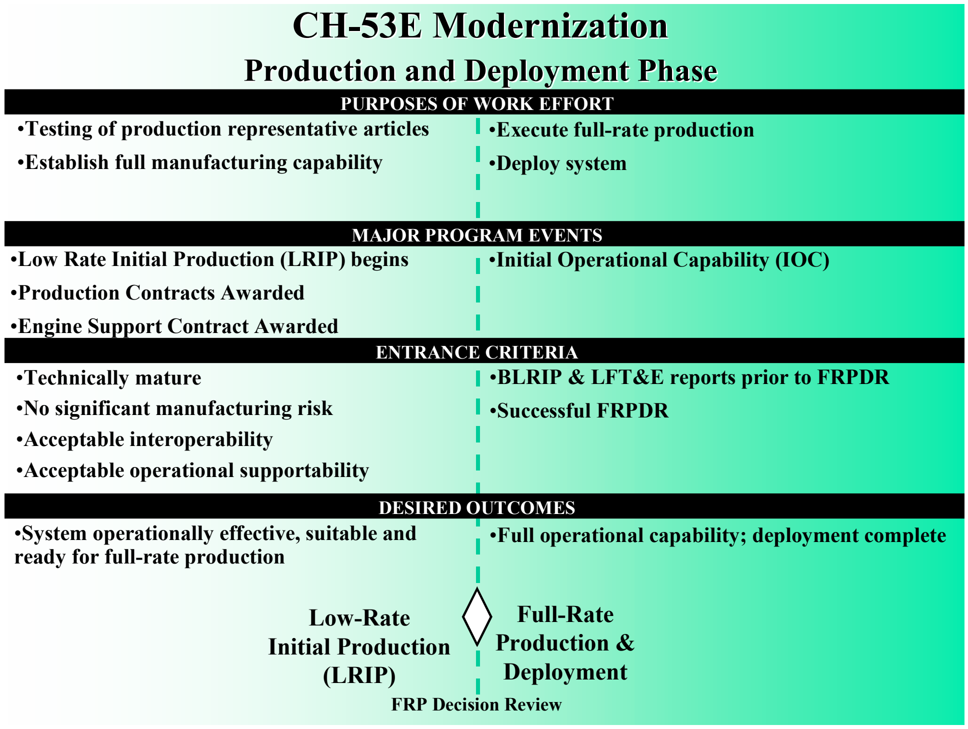

Figure 4.6 CH-53E Modernization Production and Deployment Phase [After Ref. 37]

The design should be stable at the outset of the P&D phase; the ongoing concern will be variability in aircraft induction condition for SLEP and the need to maintain fleet operational capability while in Full-Rate Production (FRP). For this reason, an incentive arrangement that adequately induces the contractors to maintain the production schedule is essential. P&D contract types and incentive arrangements may vary based on an economic analysis to determine the feasibility and benefits of Multi-Year Procurement (MYP) for each of the three major work areas; engines, cockpit and the remaining elements. An economic analysis will also be done, based on Low-Rate Initial Production (LRIP) data, to determine which, if any, components are candidates for advance procurement. The engine Integrated Logistics Support (ILS) contract will be a commercial procurement in accordance with the Federal Acquisition Regulation (FAR) Part 12.

The preliminary program structure depicted earlier provides an outline of major events and requirements in the CH-53E modernization acquisition. Subsequent sections will provide a detailed discussion of risk management, program management plan, support strategy and business strategy developed to ensure successful program completion.

3. Acquisition Approach

CH-53E modernization will use a single-step to full capability acquisition approach to meet the Marine Corps' requirement for an expanded heavy lift capability through 2025. An evolutionary approach was considered but determined to be incapable of providing an adequate heavy lift platform rapidly enough within the relevant period. However, given the difficulty in obtaining consensus among the Services as to the future shape and form of heavy lift platforms, and the possibility the CH-53E will be used beyond the 2025 time horizon, modernization must incorporate open systems architecture where possible. This is particularly true with cockpit modernization, as advancements in software and electronics will necessitate follow-on improvements to maintain battlefield parity with other naval aviation assets.

D. RISK

A program as large and complex as modernizing the CH-53E involves many facets and types of risk. Both the development effort and production effort will be discussed along with some potential tools for mitigating those risks and continuing to monitor program progress to identify new areas of risk as they arise. Figure 4.6 graphically depicts a basic risk management process that will be used to continually monitor and deal with all facets of risk within the program. IPT members will ensure that their personnel are aware of potential risks and alert the appropriate managers to changes in the probability or severity of some undesirable event.

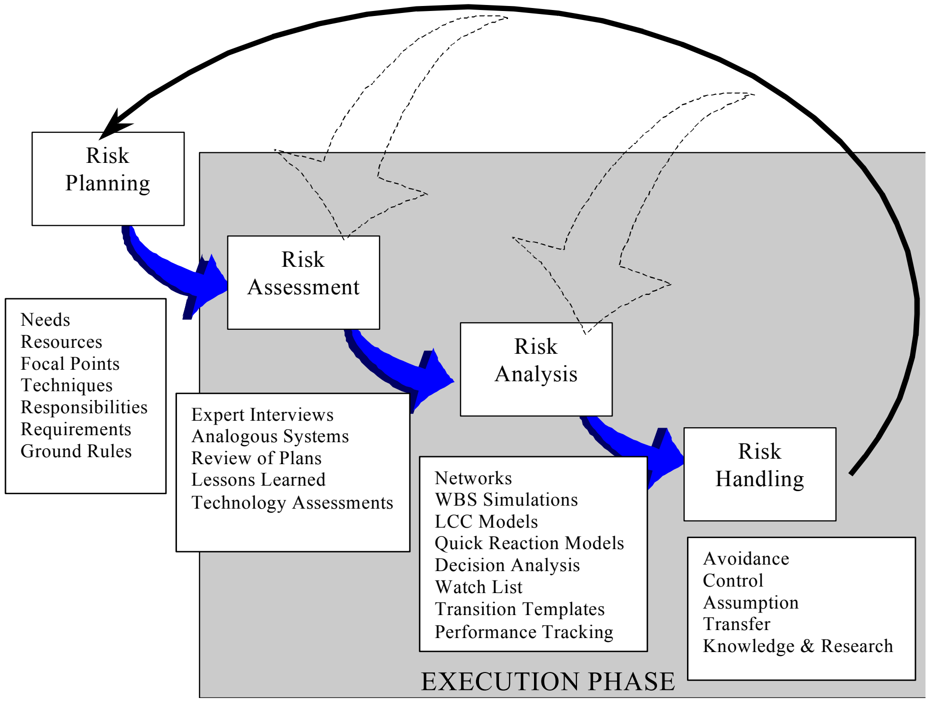

Figure 4.7 Risk Management Process [After Ref. 38]

1. Development Phase (C&TD and SD&D) Risk

The development phases contain the greatest risks in modernizing the CH-53E. Many of the risks in these phases could be classified as technical risks, such as the uncertainty about the existing drivetrain's ability to withstand the increased engine power and airfoil lift capability without increasing maintenance costs or reducing reliability. The rotor head has similar risks because the elastomeric design has not been used on a helicopter with the lift capability projected for the modernized CH-53E. Cockpit software integration and communication interoperability (compliance with the Joint Technical Architecture and Common Avionics Master Plan) present significant technical challenges as well.

While there clearly are some technical challenges, much of the difficulty arises from integrating the various modernization elements. Using proven design technologies mitigates some of this integration risk. Most of the components comprising the modernization elements are based on existing technologies, thereby eliminating much of the design risk. Gathering the appropriate stakeholders in an IPT mitigates other integration risks. In this setting, acquisition managers will be able to use flexible requirements to find common ground between the user and the contractors. Often times the user or requirements community is unaware of the enormous amounts of programmatic risk that are incurred by expanding performance ever so slightly. It is absolutely imperative that requirements be constrained so as not to incrementally increase the various technical and integration risks inherent in a complex undertaking such as this. Indeed, using a commonly-located IPT will help quickly identify and resolve interface conflicts. This also helps to foster a shared commitment to the entire project and promotes better use of the tradespace created by using the Cost As an Independent Variable (CAIV) principle.

The engine design originally called for in the CH-53E modernization proposal specified the AE1107C for commonality benefits. Yet much of the commonality benefits of using this engine would be reaped in savings related to intermediate and depot level maintenance, a function that is contracted out. For this reason, competing this requirement as a modified commercial core engine and specifying an output power target is expected to yield a greater benefit. Using a commercial core engine, sufficient data should be available to estimate and develop reliability and maintainability targets. The support portion of the engine contract is simplified by the existing recording architecture that was developed to support IMD/HUMS. With a fairly minor interface modification, the necessary engine usage data can be captured to track usage and identify maintenance intervals.

Aggressive use of an integrated EVMS and Decision Support Software (DSS), such as Logical Decisions® for Windows™ (LDW), to monitor program progress and cost effectiveness will prove invaluable as a risk management tool. This will allow decision-makers to quickly identify new areas of risk as well as make informed economic determinations of the best response. These tools are a powerful means of building the coalitions of support among stakeholders outside the program office that are necessary for programmatic success. Most importantly, these systems allow acquisition managers to continually ensure that requirements, resources and capabilities are matched in the development phases. Additionally, the incentive arrangements and business strategy described later will encourage the contractors to accept reasonable risks and reduce both technical and integration risks by working together to find quick resolutions to identified problems.

2. Production Phase Risk

While the production phase poses significantly less risk than that encountered in the developmental phases, there are some critical challenges that must be addressed. Most notably is the issue of "over and aboves." "Over and aboves" are those work elements that are not specifically called for in the contract, but are "discovered" when an aircraft is disassembled and readied for structural enhancement. Often times these elements involve corrosion and damage that cannot be known until work is actually begun. Because of the unknown nature and scope of the work that may be included in "over and aboves," SLEP programs often have trouble accounting for this uncertainty. Some of this trouble has been mitigated by the decision to replace the entire center section of the helicopter cabin, thereby reducing the need to reuse numerous structural components that may be damaged or severely corroded.

Another issue involves an unstable induction configuration. In a SLEP contract, the government is typically responsible for delivering an aircraft that meets a certain induction configuration, so the contractor has a common baseline from which to begin work and can more accurately estimate the costs of production. If this induction configuration is not closely managed, the possibility of schedule slippage and cost growth increases exponentially. A certain degree of instability is inherent with a platform that has been in service for twenty years. Therefore, the contractor must have strong incentives and be adequately rewarded for overcoming these obstacles and maintaining program schedule. Failure to do so could result in a serious degradation of fleet readiness because the modernization program will be conducted while fleet squadrons continue to support operational requirements.

Although not strictly a part of the production effort, the engine support contract will begin in the production phase. While this sort of arrangement may be new to the government, it is quite common in commercial aviation. The details of the support arrangement will be discussed in the support strategy portion of this chapter, but suffice it to say that the nature and substance of that arrangement will be based upon lessons learned under the V-22 engine Integrated Logistics Support (ILS) contract, as well as an analysis of how commercial aviation utilizes such arrangements. The overarching intent is to ensure that the engine manufacturer, who has the knowledge and experience to make design improvements, bears the design or what commercial users call the “product attribute risk.” By structuring the arrangement in this manner the engine contractor has a strong positive incentive to make continuous improvements to the engine as long as the government operates it [Ref. 39].

E. PROGRAM MANAGEMENT

1. General Philosophy and Approach

For all phases of the CH-53E modernization effort, continually exchanging information in a collaborative environment is critical to achieving success. The program will build upon the Integrated Product Team (IPT) principle in that functional experts will be asked to provide input and work together to develop innovative solutions. Additionally, all the parties including the various contractors must be committed to the program’s objectives. It is critical that the program leadership communicate the importance of having a common understanding of what is necessary to ensure program success. Success is defined as delivering a valuable asset to the fleet quickly and within cost limitations. Due to the complexity and criticality of integration in this effort, proactive steps must be taken to ease management challenges. Specifically, forming a joint government/contractor office/team helps swiftly resolve issues and contributes to a feeling of shared responsibility for program goals by all participants.

Management challenges encountered in the upgrades to the H-60 program (PMA-299) highlight the need for developing an innovative approach to integrate the efforts of several contractors. PMA-299 created a single Weapon System Integration Team (WSIT), where both prime contractors were encouraged and contractually bound to exchange information to help achieve program objectives. Rather than segmenting team efforts according to individual contractors, this approach streamlined information exchange between the contractors and quickly resolved interface and schedule conflicts. [Ref. 40] A WSIT-type program management approach is recommended to integrate the various contractors who will work on CH-53E modernization.

As a recent GAO report observed, "programs that were meeting product development objectives had more effective teams than programs that were having problems. In addition to meeting objectives, the successful programs were often surpassing the performance of their predecessors in both time to market and performance." [Ref. 41] Clearly, greater performance and reduced cycle times will be the goal of the various IPTs. To achieve this, CH-53E modernization IPTs need to have the knowledge necessary for informed decisions and the requisite authority to make those decisions. To arm them otherwise dooms the program to gridlock and frustration. Without coordinating key IPT personnel, significant integration challenges could overcome the program. While the ability of empowered teams to tackle and overcome difficult problems is impressive, they are not the answer to every issue. The program office must resist the urge to proliferate teams for every project. Doing so degrades their importance and drains personnel of their motivation.

A significant institutional barrier that must be hurdled is the "business as usual" attitude. Modernization efforts are nothing new, yet as mentioned earlier, there are few if any salient successes. Therefore, acquisition managers should encourage their people to challenge the status quo; history indicates that the best solution is yet to be found. Efforts should focus on simplicity, affordability, and supportability. While performance improvements may gain short term recognition, all personnel involved need to realize that there are many lessons to be learned from twenty years of historical data that can be put to good use in modernizing the CH-53E. To ignore this wealth of information would be a tremendous tragedy. Paying attention to the lessons from the past will aid in mitigating programmatic risk and make the program much easier to defend and rationalize to external stakeholders.

2. Resources

Advance procurement of costly and long-lead time components could provide significant cost savings for the program and therefore should be at the forefront of acquisition managers' minds as the production phase approaches. Because the program production schedule will be driven, but also constrained by the need to keep the fleet operational, fewer aircraft may be modernized in a given period than the efficient production rate for some critical components. For example, the rotor head will be a particularly costly item to produce and savings may accrue if production could be limited to one continuous run. However, to comply with the full funding requirement specified in DoD Regulation 7000.14-R, lots can only be purchased to cover two years' production quantities. A similar principle could hold true for the rotor blades. An economic analysis therefore should be planned as the production phase nears to determine which components have sufficiently stable designs and would reap savings through increased efficiency and learning created by a continuous production run.

3. Tailoring and Streamlining Plans

CH-53E modernization elements were chosen largely around developed technologies, thereby reducing the design and engineering work necessary to enhance a weapon system's capability. By emphasizing non-developmental items as modernization elements, more attention can be focused on correcting existing maintainability and supportability issues. Additionally, the present plan uses a commercial core engine for the engine modernization, as well as a commercial support arrangement for the engine. This will help streamline the acquisition and should provide the Marine Corps more efficient service because the engine manufacturer has a positive incentive to keep the engine on wing as long as possible. This also provides a continuous incentive for design and engineering improvements on the engine, which should produce greater reliability, availability and reduced sparing requirements.

ACAs and a WSIT-type joint development office/team will help quickly resolve design and schedule conflicts. It also provides a single point of interface between the program office and all contractors. This promotes more effective and efficient use of program office personnel. Additionally, using an Integrated Master Schedule and EVMS by all contractors will provide the program office with a single means of tracking program progress and integrating contract management.

F. DESIGN CONSIDERATIONS AFFECTING THE ACQUISITION STRATEGY

Perhaps the greatest design consideration affecting the acquisition strategy is the necessity to use Sikorsky Aircraft Corporation (SAC) as a sole-source supplier for a majority of the modernization effort. Nonetheless, the design of the modernization elements has focused on currently developed technologies that only require modification for use on the CH-53E. Open systems will be specified, particularly in rapidly evolving industries such as in communications and electronics equipment and software for the cockpit. Interoperability and commonality standards, such as compliance with the Joint Technical Architecture interfaces, as well as CAMP, will also be a requirement for the cockpit.

Acquisition managers must focus both the user and contractor to develop and address the potential design implications on aging components. While the six modernization elements focus on some of the leading problems facing the CH-53E due to its age, failure to estimate and validate the potential impacts of modernization will yield useless performance enhancements due to decreased readiness and maintainability. The program is currently structured such that the economic analysis performed at the IPR in the SD&D phase is a final affirmation that modernization will result in greater reliability and maintainability, not just performance. If this is not the result of that review, serious consideration must be given to new procurement. Yet even after the IPR, the intent of using a DSS, such as LDW, for acquisition managers is to provide them with an ongoing scorecard to ensure sunk costs are not the basis for continuing a program with uncertain long-term consequences. Modernization represents a second chance to address the original design errors; failure to do so will exacerbate the current aging problem described earlier and therefore should remain a primary design consideration throughout the evolution of the acquisition strategy.

G. SUPPORT STRATEGY

Even as the cost of supporting aging aircraft continues to escalate, recent audit reports by the Naval Audit Service and GAO highlight the Services' failure to place sufficient priority on developing effective support strategies that reduce O&S costs for major weapon systems [Ref. 42, 43 and 44]. And yet, despite the challenges described earlier in obtaining and using the current O&S cost data on the CH-53E, there are some clear lessons that can be applied to this acquisition and the subsequent development of the accompanying support strategy.

The research of Dr. L. Stoll and Mr. R. Ernst provides some important insight into the symptoms common to aging helicopters. As mentioned earlier, all aging aircraft tend to experience operating and support cost growth. Yet this cost growth is usually not the result of the aging airframe, but rather aging components or AVDLRs. As Figure 4.8 indicates, helicopter and engine AVDLR cost growth drivers are almost exclusively caused by aging. Therefore, it is logical that any modernization effort must account for this and look at those AVDLRs currently experiencing cost growth and ensure that they are addressed as part of the modernization effort. [Ref. 21]

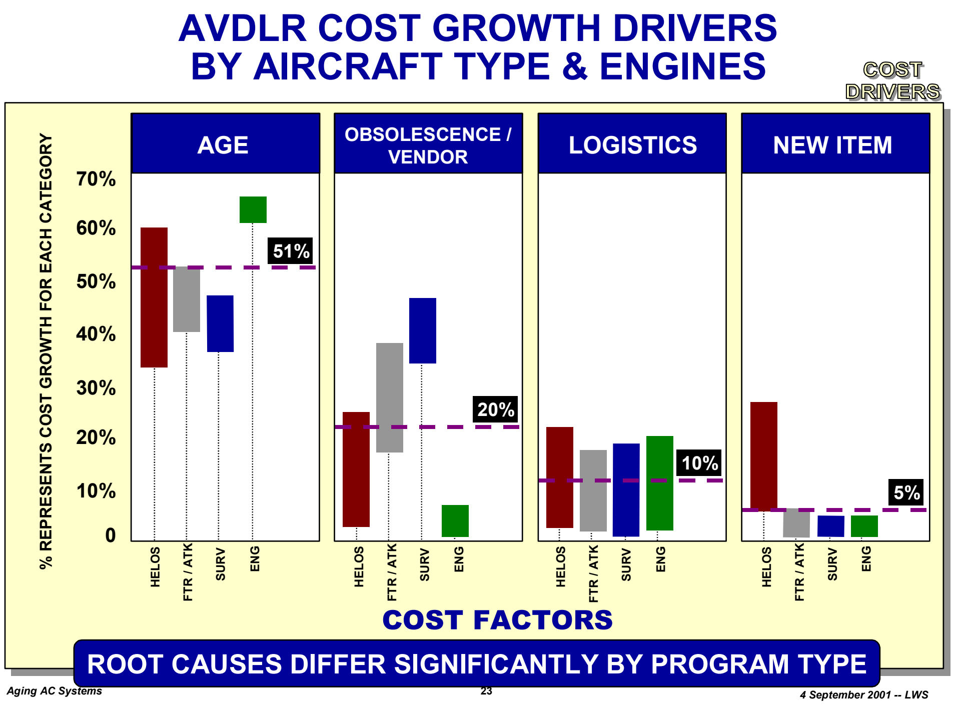

Figure 4.8 AVDLR Cost Growth Drivers By Aircraft Type and Engines [Ref. 21]

As it happens, the categories of AVDLRs most affected by aging also vary by aircraft type. Not surprisingly, helicopter dynamic component AVDLRs (rotary blades, gear boxes and associated items) accounted for most of the cost growth drivers by item count (see Figure 4.9). However, the real cost impact becomes clear when the dollar value for those dynamic component AVDLRs is compared with the other item categories (see Figure 4.10), where dynamic components account for approximately 64% of the dollar value cost growth.

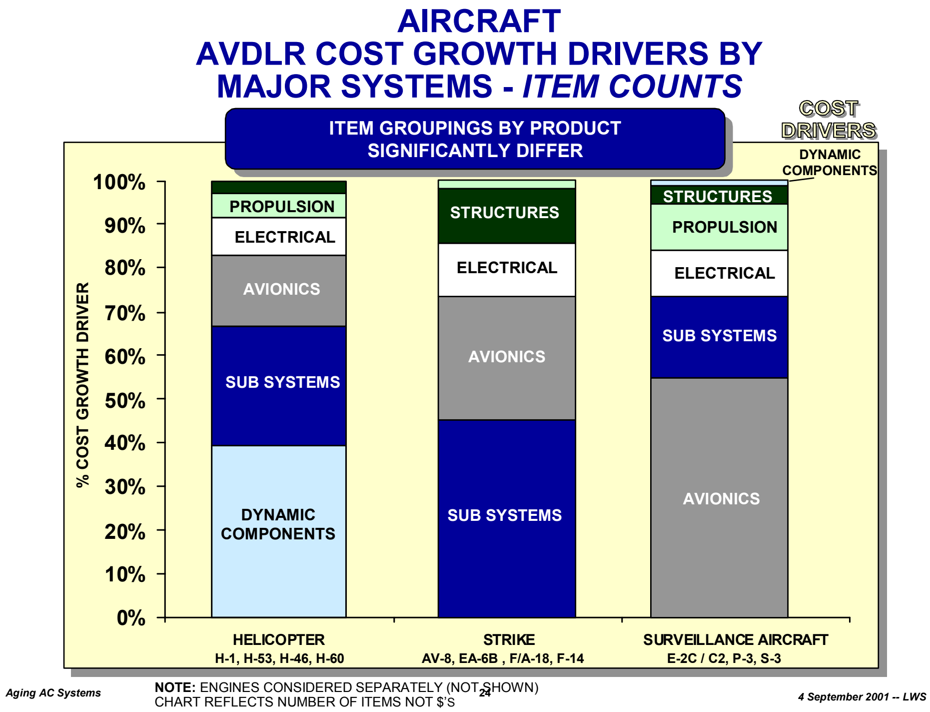

Figure 4.9 Aircraft AVDLR Cost Growth Drivers by Major System [Ref. 21]

Detailed Data Showing AVDLR Item Counts and Associated Costs

		Avg FY2000 Cost/Item	Total Items	Total VAD FY2000	Comparative Statistics	
Surveillance A/C	Average	42,738	9,856	159,388,256	TOTALS	
		Count	Sum Items	Sum Dollars	Sum Dollar%	Count%
	Avionics	41	4,245	65,110,365	41%	55%
	Dynamic Components	1	13	585,761	0%	1%
	Electrical	8	2,441	30,140,408	19%	11%
	Propulsion Related	8	1,817	40,225,842	25%	11%
	Structures/Airframe	3	238	3,549,211	2%	4%
	Subsystems	14	1,102	19,776,670	12%	19%
	Totals	75	9,856	159,388,256	100%	100%
Fighter/Attack	Average	37,165	11,079	167,045,288	TOTALS	
		Count	Sum Items	Sum Dollars	Sum Dollar%	Count%
	Avionics	27	4,321	52,591,569	31%	28%
	Dynamic Components	0	0	0	0%	0%
	Electrical	12	1,308	16,917,902	10%	12%
	Propulsion Related	2	1,142	5,369,990	3%	2%
	Structures/Airframe	11	408	16,431,537	10%	11%
	Subsystems	45	3,900	75,734,290	45%	46%
	Totals	97	11,079	167,045,288	100%	100%
Helicopters	Average	51,628	12,148	252,632,957	TOTALS	
		Count	Sum Items	Sum Dollars	Sum Dollar%	Count%
	Avionics	15	1,690	22,930,355	9%	15%
	Dynamic Components	41	2,966	161,282,844	64%	41%
	Electrical	9	1,337	15,081,817	6%	9%
	Propulsion Related	7	2,152	22,047,315	9%	7%
	Structures/Airframe	2	258	2,662,175	1%	2%
	Subsystems	25	3,745	28,628,451	11%	25%

Aging AC Systems 25 4 September 2001 -- LWS

Figure 4.10 AVDLR Item Counts and Associated Costs [After Ref. 21]

The results of this research are particularly important for modernizing the CH-53E because, while the blades, rotor head and engines are in part being addressed in modernization, other dynamic components such as drive shafts and gearboxes are not. It is absolutely imperative that the assumptions about the strength of the current drivetrain are validated early in the modernization acquisition so as to preclude an exponential O&S cost growth as already aging dynamic components are placed under greater stress. This is the primary purpose of the extensive component development effort prior to program initiation. Additionally, the use of the IMD/HUMS system currently being fielded to the fleet will be a powerful tool for acquisition and logistics managers in evaluating and validating the potential impacts of the various modernization elements, undoubtedly saving aircraft and lives throughout the CH-53E's deployment.

A continually evolving support strategy based on careful analysis and evaluation of the modernization elements' impacts must be developed concurrent with the rest of the acquisition strategy. Support strategy initiatives should focus on continually improving system affordability, reliability and supportability while meeting readiness targets. One means of achieving this objective is by testing critical components early and thoroughly during the C&TD and SD&D phases to validate and discredit exaggerated MTBFs that naively understate future O&S costs. Additionally, the incentive structure for the various modernization elements should incentivize the contractors to incorporate reliability and maintainability improvements into their design, as well as utilize Value Engineering Change Proposal (VECP) clauses.

The CH-53E modernization support strategy will continue to rely on organic sources of support, with the exception of the proposed engine support contract. That will rely on CLS for intermediate and depot level engine maintenance. As mentioned earlier, CLS arrangement was chosen in anticipation of reduced maintenance costs, greater reliability over the life of the engine, reduced sparing requirements and greater engine availability. While the reduced maintenance costs are difficult to estimate, some of the other benefits are clear, based on fleet hour agreements in the commercial aviation market [Ref. 39].

Nonetheless, the CH-53E, like most tactical military aircraft, is flown differently than commercial aircraft and therefore, adjustments are needed to the support agreement. Most notably, provisions must be made to ensure that ESMHs, missions, and flight hours are tracked and correlated so that the rate being applied (charged) remains accurate over time [Ref. 45]. This provides the government with the ability to evaluate the accuracy of the rate being charged. If there is a gross or consistent inaccuracy, the method used to calculate ESMHs should be reevaluated. Another concern is over engine data loss that results in applying penalty hours, which are typically billed at two and a half times the normal rate [Ref. 46]. Failure to anticipate these sorts of problems could lead to significant cost growth in the engine support contract.

Some political considerations that must be accounted for in choosing a CLS arrangement are the backlash that will likely be generated by the depots and their political supporters. Additionally, and perhaps even more problematic, is the manning issue. While the program office has indicated that they would like a CLS arrangement, there are no plans to reduce intermediate or depot level uniformed work forces. If the engine work for both the V-22 and CH-53E are provided by CLS, it will become increasingly difficult to justify not reducing manning levels in those units. These political considerations must be carefully weighed and may result in a traditional in-house support plan. If this is the case, a new way must be found to ensure the contractor has a stake in keeping engines on wing as long as possible (disincentive for bare firewalls).

Unlike with the engine, the cockpit design and support stands to benefit by using common "boxes" available through the Combat Electronics Program Office (PMA-209) to reduce logistical support costs. However, a non-developmental cockpit that meets the basic user requirements may be available from Sikorsky. This issue will be discussed in the following section. Suffice it to say that the benefits of a ready, integrated cockpit may outweigh commonality logistics savings. Again, an economic analysis should determine which course of action is most appropriate. In any case, the desire of the user community to over-specify the cockpit requirement must be constrained.

H. BUSINESS AND CONTRACTING STRATEGY

The business strategy developed for CH-53E modernization resulted from careful analysis of this procurement as well as lessons learned from other programs. In particular, experiences from two programs, the H-1 Upgrade and H-60R/S programs were the primary sources used to develop this unique and tailored strategy. Of course, this strategy represents a preliminary interpretation based upon the current modernization element design and competitive environment. Scope of work and technical changes could alter to this strategy. Additionally, the preponderance of effort was placed on the development phases of the strategy, because the information currently available is more pertinent to those phases. For example, MYP may prove to be a feasible and beneficial strategy for production, but more detailed design and engineering information is required along with a thorough economic analysis to determine whether there are EOQ gains from pursuing this and to confirm that the requisite funding is available.

The business strategy described below is crafted to maximize competition where possible, incentivize outstanding contractor performance, reduce the time required to meet the warfighter's requirement and provide the best value to the government. Discussion and analysis is divided into the three acquisition management phases in which the three modernization work areas are analyzed.

1. Concept and Technology Development Phase

This phase will begin by establishing the program office portion of the WSIT. Contracts will be awarded to conduct trade studies to evaluate current market capabilities. A sole-source Cost-Plus-Fixed-Fee (CPFF) type contract will be awarded to Sikorsky to begin work with the program office to construct the Joint Statement of Work (JSOW), common WBS and Integrated Master Schedule (IMS) for the entire modernization development effort. Draft Associate Contractor Agreements (ACAs) will also be drawn up for engine and cockpit manufacturer evaluation. Multiple competitively-selected engine and cockpit design and demonstration contracts will be awarded to various contractors. The winning contractors will then compete for final award of the engine and cockpit portions at the beginning of the SD&D phase.

A pre-solicitation conference and draft Request For Proposals (RFP) will be used to develop the RFP to award multiple design and demonstration contracts to aircraft engine manufacturers. Prospective engine contractors will be asked to design a commercial core, modified turboshaft engine that meets user-specified performance ranges and Sikorsky-specified interface requirements. The RFP will state that engine contractors will be required to sign ACAs with other modernization contractors should they be selected for the subsequent phase. Additionally, engine contractors will be informed that if selected for award to the subsequent phase, they will be required to provide a priced intermediate and depot level support proposal, akin to the commercial Fleet Hour Agreements (FHA) sold in the commercial aviation market. CPFF or Firm-Fixed-Price Level-of-Effort (FFP LOE) type contracts will likely be used for the engine design and demonstration contracts. The number of contracts awarded will likely be constrained to between three and five to allow conscientious evaluation of each of the designs; developmental funding limitations will also be a constraint.

In this phase, engine manufacturers should also be consulted about their willingness to enter into a government-industry partnership where touch labor for intermediate and depot level maintenance would be subcontracted to the Naval Aviation Depots (NADEPs). Contractors would thereby maintain the "product attribute risk," providing a positive incentive for continuous product improvements, while the depots did not lose any work. Clearly, orchestrating such an agreement would be difficult yet it does have several positive effects. Most notably, the political quagmire usually encountered when trying to take work out of the depots is avoided, yet the Government retains the organic capability to perform this critical maintenance. Additionally, improved designs would likely result in higher reliability, maintainability and a lower spares requirement. Naval Inventory Control Point-Philadelphia (NAVICP-P), NADEP Cherry Point, North Carolina and Honeywell successfully orchestrated such an arrangement to support several aircraft Auxiliary Power Units (APUs) [Ref. 47].

Evaluating and selecting the winning engine design should be based upon drivetrain impacts as determined by both simulation and prototype testing. For this reason, prospective engine contractors must have access to information from Sikorsky on the possible downstream effects of engine output and design might be. Evaluation will also be based upon past reliability and maintainability of the core engine and the number and scope of modifications needed to construct the CH-53E modernization engine. Additionally, output performance and reliability will also be evaluated. Total system O&S cost impact, however, should be the greatest evaluation factor.

A similar pre-solicitation and draft RFP process as that used to solicit RFP input for engine designs will be used to draft the cockpit avionics design and demonstration RFP. Similarly, multiple competitively-negotiated CPFF or FFP LOE contracts will be awarded to several cockpit manufacturers and integrators for the design and demonstration of cockpit avionics suites. Current research indicates that Sikorsky will likely compete as an integrator for this portion. They, along with three to four others, will be allowed to compete. Cockpit contractors must also be willing to sign an ACA with other modernization contractors should they be selected to provide the cockpit.

Cockpit competition evaluation will be based on commonality and interoperability compliance outlined in the Common Avionics Master Plan (CAMP), non-developmental designs of components and open systems architecture based upon industry standards. Designs will also be evaluated on Human Systems Integration and basic performance requirements. However, because the CH-53E cockpit is not as space constrained as other platforms, deviations from standard designs should be avoided. Evaluations should focus on minimizing developmental costs and maximizing the capability for upgrades and technology refreshment as these components continue to advance. More so than the engine competition, this will be a cost/price competition since most components should have similar capabilities and performance. However, because the cockpit must be integrated with current system software, software development capability (as specified by the Software Engineering Institute's (SEI) Capability Maturity Model (CMM)) will be a critical selection factor because successfully integrating the cockpit is essential to overall program success.

The remaining modernization elements undergoing advanced development and proof of principle demonstration by Sikorsky in this phase will be used in the subsequent phases to determine total system and component reliability, maintainability and supportability factors. Component performance in these areas in the subsequent phases will be the basis for incentive payments and therefore contractors, particularly Sikorsky, will have a positive incentive to invest in developing high-reliability components.

If developmental funding is seriously constrained, a more careful analysis will be required to see if the positive effects of competition support the additional investment in multiple designs. However, it should be remembered that the effects of competition here extend beyond price factors. Specifically, because total system O&S cost impact is the primary evaluation factor in both the engine and cockpit designs, there should be a fair degree of variability in design innovation that cannot be replicated without competition. Therefore, despite the greater outlay of investment capital required in the development phase, competition here will likely yield tenfold savings over the life of the system, and thus should be staunchly defended. Nonetheless, if funding is constrained, consideration should be given to making minor modifications to the Sikorsky "international" cockpit to meet CAMP and JTA requirements rather than eliminating the engine competition from this phase.

2. System Development and Demonstration

This phase will mark the initiation of a new program as well as the selection of the engine and cockpit contractor based on the best value competition that will culminate in product principle validations and demonstrations. This phase is by far the most critical for the modernization effort. Therefore, it should receive the requisite amount of attention from acquisition managers when planning its development and execution. This phase requires successfully integrating the various modernization elements, which upon exiting the previous phase were considered to be mature enough to support integration and program initiation without incurring too great a risk.

The source selection of both the engine and cockpit contractor made at the outset of this phase will result from an ongoing evaluation of the design and product demonstration results of the previously-awarded CPFF contracts. Selection criteria will be much the same as before, but should be further refined as more product design and capability information becomes available. The selected engine and cockpit contractors will now become an integral part of the WSIT. With the final WSIT members identified, their input will be taken to continue to refine and improve the JSOW, common WBS and IMS. With the aid of government acquisition mangers, the ACAs between the various contractors will be finalized. Draft ACAs generated by Sikorsky and the Government should be provided in the CT&D phase. The ACAs will be tailored to the WBS and detail rights and responsibilities of each of the parties. While this process will require significant commitment of all WSIT members, the benefits will be reaped throughout the subsequent phases. Table 4.2 illustrates the ACA responsibility matrix excerpted from the H-60 program agreement between Lockheed Martin Systems Integration – Owego (LMSI-O) and Sikorsky (SAC).

Table 4.2 H-60S AMCM ACA Amendment Responsibility Matrix [Ref. 48]

LMSI-O	SAC
Interface Management Team	Interface Management Team
AMCM Leadership IPT	AMCM Leadership IPT
AMCM Weapon System Integration IPTs	AMCM Weapon System Integration IPTs
Support Master Integrated Program Schedule (MIPS)	Develop and Maintain Master Integrated Program Schedule (MIPS)
Manage Electrical Engineering Working Group	Manage Mechanical Engineering Working Group
Earned Value Measurement for LMSI-O contract and WSIT monthly report	Earned Value Measurements for SAC contract and WSIT monthly report
Alternate lead for Program Reviews (Integrated Baseline Review, System Design Review, Preliminary Design Review, and Critical design Review), including development of meeting minutes	Alternate lead for Program Reviews (Integrated Baseline Review, System Design Review, Preliminary Design Review, and Critical design Review), including development of meeting minutes
Develop and Maintain Program Management Plan	Support Program Management Plan
Technical Performance Measures for LMSI-O contract and WSIT monthly report	Technical Performance Measures for SAC contract and WSIT monthly report
Support Contract Work Breakdown Structure	Develop and maintain Contract Work Breakdown Structure
Alternate lead for Program Status Reporting	Alternate lead for Program Status Reporting
Develop and Maintain Systems Engineering Management Plan and Systems Engineering Development Plan	Support Systems Engineering Management Plan and Support Systems Engineering Development Plan
Maintain AMCM DOORS database	Support AMCM DOORS database
Support AMCM risk database	Maintain AMCM risk database
Support Automatic Flight Control System with cockpit modifications	Design and incorporate updates for the Automatic Flight control system. (Being performed under a separate Contract)
Support integration of the Carriage, Stream, Tow and Recovery System	Manage the integration of the Carriage, Stream, Tow and Recovery System
Manage development Mission Avionics Kit	Support development Mission Avionics Kit
Support Mission Avionics Integration into the aircraft	Manage Mission Kit Integration into the aircraft
Develop and Maintain AMCM system architecture and documentation	Support AMCM system architecture and documentation
Design and build portable test rack and common console	Support development of portable test rack and common console
Support development and maintenance of mission kits	Develop and maintain mission kits
Support development of installation provisions for the Tactical Common Data Link	Develop installation provisions for the Tactical Common Data Link
	Ensure Cabin Primary Emergency Egress/Rescue System (PEERS) requirements are met
Support weight control program	Develop and maintain a weight control program, including updating the Weight Control Handbook
Support cabin layout design	Coordinate cabin layout design utilizing digital mockup
Configuration Management Board and CM of Mission Avionics Kit	Configuration Management Board and CM of Aircraft and mission kits

Notice the level of detail outlined in the matrix and the interdependence between parties. Furthermore, the details and actions specified in the ACA correlate directly with the JSOW and common WBS.

The subsequent contracts in this phase should be Cost-Plus-Award-Fee for all contractors involved. This phase will likely span two to three years; each contract should be tailored to the work to be performed during the period. Options during this phase are not anticipated, although they may be used if the contractor is not adversely affected by the arrangement. The incentive structure in this phase is critical to success. Specifically, a majority of the award fee pool for each of the contractors should be tied to WSIT performance. Additionally, award fee evaluations should take place at program milestones, such as the System Design Review (SDR), rather than arbitrary calendar dates. By tying a majority of the award fee to total team performance at program milestones the various contractors have a shared incentive for outstanding performance. Similarly, if they fail to reconcile problems they are both "punished." Because the modernization elements themselves should have fairly stable designs at this point, the critical obstacle to success is integration. Under this sort of arrangement, contractors have a vested interest in meeting schedule and resolving conflicts quickly. During the latter portion of this phase (System Demonstration), consideration should be given to including liquidated damages clauses to ensure contractors meet schedule "gates."

Ensuring that the work of the various contractors is properly integrated and continues to progress is often a difficult task for a program office. Even with a single prime contractor, as with the H-1 Upgrade program, significant challenges were encountered that hampered both the contractor and the program office from realizing the severity of the problem until it had grown considerably [Ref. 34]. By virtue of forming the WSIT and subsequent JSOW, WBS and IMS, integrated contract management problems become immediately visible because each of the contractors relies on these systems to schedule their work and input into the effort. While this sort of visibility may make some program managers uncomfortable, it helps detect and resolve even the smallest issues more rapidly. It also requires the contractors to communicate with each other, giving all concerned parties greater clarity on the total system schedule.

Of course a portion of the award fee pool for each of the contractors should be used to reward individual contractor element performance. However, this should be a relatively small amount compared to the WSIT award fee performance pool. Clearly, the program office has to be the focal point of planning and coordination between the contractors. While this responsibility, when coupled with managing the award fee incentive, may be burdensome to acquisition managers, it is nonetheless the most effective and efficient means of coordinating the contractors' complex efforts.

Consideration should be given to the including specific dispute resolution language into the ACAs. The Government should not become involved in such disputes unless asked to intercede by both parties. Additionally, it would likely be helpful if all parties concerned had procedures in place to handle the inevitable conflicts that occur and allow the program to continue to progress while steps are taken to reach a resolution.

3. Production and Deployment

As mentioned earlier, many of the details of this phase will depend on how the program has progressed and developed up to this point. While the ACAs that were developed in the previous phase will continue to be used, during this phase the contractors are not as interdependent upon each other. This phase includes Low Rate Initial Production (LRIP), where the demonstrations conducted in the previous phases are further refined and production methodologies and practices are certified.

The LRIP and initial production contracts should be Fixed-Price-Award-Fee. The incentive arrangement will remain largely the same as it did in the previous phase where

WSIT performance determined the distribution of a majority of the award fee pool. Once production pace and procedures have stabilized, consideration should be made to utilize a Firm-Fixed-Price (FFP) type contract. Additionally, it is at this point that, funding permitting, establishing a MYP for the whole effort, should be considered, as well as advance procurement of some high value long-lead items that are likely to reap learning curve benefits that will reduce the Government's cost. Of course, the economic analysis would have to account for the production limitation (only two years) that must be applied to items or components purchased using advance procurement funds. Consideration should also be given to competing out IDIAT on later production runs to ensure contractors continue to control costs and that the additional risk incurred appears acceptable.

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V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

1. The Lust for New and Greater System Performance Tends to Dominate All Other Requirements

While this provides American fighting forces with the most capable weapon systems in the world, it does so at great expense. New and aging systems alike tend to accept high levels of programmatic risk and blindly buy into optimistic Life Cycle Cost (LCC) estimates. This fate has yet to befall the CH-53E modernization effort, however, it is threatening an attack as various stakeholders inside and outside the user community begin to add to the growing list of modernization requirements and known O&S cost drivers receive less and less attention. The discussion and analyses in Chapters III and IV outlines some of the programmatic risks and challenges acquisition managers involved in modernizing the CH-53E should heed if they wish to stem the tide of growing O&S costs associated with their aircraft and actually deliver a more capable and reliable platform.

2. There Are No Modernization Success Stories that Provide Easy Solutions for Acquisition Managers

Aging systems should, in theory, have the advantage of experience over new programs. After all, the data are there, or should be, to identify which areas are degrading reliability and driving costs upward. However, there are few success stories of programs adequately ameliorating the affects of aging airframes and concurrently refreshing capabilities. This is often the result of the overwhelming force of "take-all-you-can-get-when-you-can-get-it" user communities who feel, and have been, starved of adequate funding to maintain operational parity with other platforms. Yet making dramatic capability leaps with aging systems is fraught with more perils than with new systems. As this thesis has documented, the complexities of modernization are difficult to address and not easily understood. Indeed, the challenges discovered in this research by no means capture the entire spectrum of difficulties that may be encountered in modernizing such a complex system. To the student of major weapon systems acquisitions, trying to organize and capture all the pertinent issues involved in developing a coherent acquisition strategy for an undertaking of this magnitude is truly humbling.

3. Determining the Effects of Modernization and Aging On Dynamic Components Is the Critical Issue for CH-53E Modernization

For the CH-53E modernization acquisition strategy, the demonstrated impact of aging on dynamic components combined with the potential effects of modernization on the existing dynamic components must be carefully evaluated and monitored. Acquisition managers allowing themselves to "buy in" to overly optimistic presumptions of these impacts will likely observe astronomical O&S cost growth accompanied by declining readiness rates and perhaps even catastrophic failures. Additionally, the drive for greater performance will encourage acquisition managers to minimize the significance of this issue. Failing to ensure this issue is resolved before key program decisions will likely lead to disastrous results. This is by far the greatest facet of risk to the proposed modernization and should be of primary concern to program and acquisition managers as well as users.

4. Using Decision Support Software to Facilitate Ongoing Economic Analyses of Program Progress Will Lead to Better Decisions

This research explored the issues involved in addressing the aging phenomenon at an early stage, prior to the formal initiation of a program or receipt of funding. While this made it difficult to collect some data, there are some clear benefits. Specifically, the use of a DSS such as LDW, and the construction of an economic cost effectiveness model that can be used as an ongoing decision aid for program managers, may yet prove to be invaluable. Additionally, it provided an opportunity for program personnel to begin to consider some of the issues involved in modernization and organize their thoughts and actions toward addressing those issues.

5. Common Program Offices and Teams within NAVAIR Are Unlikely to Realize Full Potential Because of Current Funding Arrangement

A supplementary conclusion was made while conducting this research regarding the obstacles to success of non-aircraft PMAs and other indirectly funded entities, such as PMA-209 and the Aging Aircraft IPT. While these organizations offer valuable experience and expertise to the various aircraft program offices, they are overwhelmingly seen to be funding parasites. While not funding them directly ensures a certain incentive for efficiency, it also serves as a strong disincentive for program managers of aircraft PMAs to utilize such organizations because it requires them to sacrifice control of their funding to procure some good or service they can usually obtain themselves through normal channels. Given this funding arrangement, it makes it very difficult for such organizations to receive the funding necessary to pursue opportunities for cost savings or reliability improvements because Program Managers have little incentive to relinquish control of their funding. As long as this situation persists, it seems unlikely that these organizations will succeed addressing the numerous problems common to many Naval aviation platforms.

B. RECOMMENDATIONS

1. Early and Continuous Dialogue between Users, Acquisition Managers and Contractors Is Needed to Match Resources and Expectations

Much of Chapter IV serves as a recommendation for proceeding with the CH-53E modernization. However, acquisition managers must actively engage the user and requirements community and educate them concerning the perils and pitfalls of major weapon systems acquisitions. It seems that all too often they fail to realize the potential programmatic impacts of inflexibly approaching requirements. The reality is that these programs live and die in a politically-charged environment. Ignoring or choosing to disregard that environment only serves to endanger a program's chances for achieving cost, schedule and performance objectives. Additionally, acquisition managers must serve as a conduit between the contractors and the users; keeping each party informed of changes and challenges as the program progresses. Failure to do this will inevitably lead to a mismatch between user expectations, program funding and/ or contractor capability.

2. Acquisition Managers Must Innovate New Strategies Tailored to Platform Specific Technology and Needs

While it is unlikely that the acquisition strategy developed in the previous chapter will be followed or acted upon exactly, it does provide a basis of departure. The methods it presents for mitigating risk, incentivizing outstanding contractor performance, reducing O&S costs and delivering the best value to the government are not the only methods, but they do address the salient issues that acquisition managers should consider as they approach the challenge of modernizing the Marine Corps' CH-53E Super Stallion. More importantly however, this strategy highlights the need for acquisition managers to continually seek out new and innovative approaches to ameliorating the insidious effects of aging on our fleet of aircraft. Clearly there is no single recipe for success for all platforms. Acquisition managers must carefully analyze the distinct requirements of each program and developing a tailored approach that addresses those requirements such as was done for the CH-53E modernization in Chapter IV.

3. Early Testing and Validation of Effects on Dynamic Components Should Be Used to Pace CH-53E Modernization Program

In order to ensure that CH-53E modernization achieves its objectives, acquisition managers should utilize aggressive testing and validation schemes to confirm the effects of modernization on aging dynamic components are known prior to program initiation and progression. This issue represents the Achilles heel of the program and managers must not allow external pressures to minimize its significance. Because of the far reaching implications in cost, reliability, maintainability and safety, the condition of key dynamic components must be continually monitored and evaluated to ensure that modernization is indeed the most effective means of meeting user requirements.

4. Use Decision Support Software and Update With Test and Cost Information for More Informed Decisions

This research clearly demonstrates the value of continually using of LDW, or a similar DSS type tool to monitor and evaluate requirements generation, performance output and cost changes to ensure that they are in keeping with program goals and funding levels. Such a tool is also useful for gaming out stakeholder evaluation of program performance. It allows program personnel to substitute the preferences of various leaders or evaluators and objectively measure program performance. LDW or similar DSS is also a powerful tool for PMs in making ongoing economic value assessments of program progress, i.e. modernize or buy, multiyear procurement, and advance procurement. It also helps quickly identify disconnects between costs and effectiveness. However, it must be continually monitored and updated so that timely action can be taken to resolve these issues. Additionally, once the basic model has been constructed, it can rather easily continue to evolve to capture the growing program complexity. For this reason, it is recommended that acquisition managers consider adopting such a tool early in program development in order to continually use as a decision aid.

5. Fund Common Program Offices and Teams Directly So Aircraft Program Offices Have an Incentive to Utilize Them

If NAVAIR truly wants to leverage the effectiveness of these common organizations, they must be funded directly by the Program Executive Offices (PEOs). Otherwise, they will continue to be perceived as well intentioned and capable funding parasites. By de-politicizing the funding issue, common program offices and teams are free to focus their attention and energy on addressing critical problems facing many naval aircraft rather than competing for funding with individual aircraft program office initiatives. Additionally, because their services are offered free to the aircraft program offices, managers are much more likely to heed their suggestions and utilize them to the benefit all parties involved.

C. ADDITIONAL AREAS OF RESEARCH

It is the author's sincere intention that this work will add to the body of knowledge of acquisition research and that others will follow behind and continue to document the progress of the CH-53E and other aging aircraft. Therefore, it would be helpful if this work would serve as an opening chapter in a case study documenting the CH-53E's journey through the acquisition process and evaluate whether the recommendations and observations suggested in this work were accurate, relevant and or helpful to acquisition managers.

Clearly, there is a great deal more research that must be done to prepare for this particular acquisition; in particular more research needs to be done to try to develop some common methodologies or tools that can help acquisition managers deal with modernizing aging systems. While it is clear that there are no cookbook answers to these complex problems and no two situations are exactly alike, there is an opportunity to learn from the successes and failures of others.

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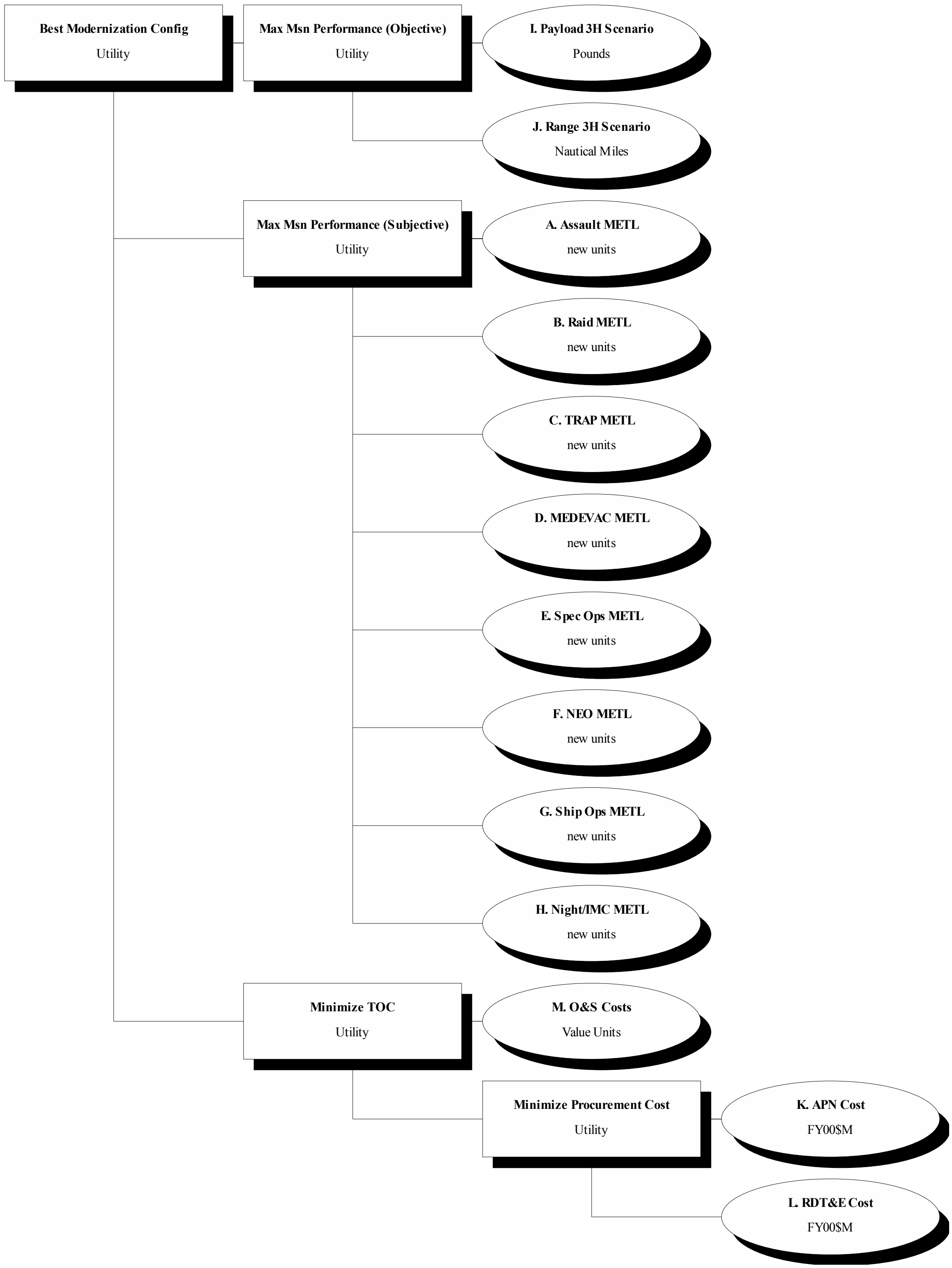
APPENDIX A. LDW GOAL / MEASURE HIERARCHY



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APPENDIX B. PROCUREMENT COST MODELS

LOW		RDT&E FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	TOTAL
	Design & Eng. SLEP	7.4	9.8	4.9	2.5	0.0	0.0	0.0	0.0	**25**
	FTA	0.0	18.9	32.3	2.7	0.0	0.0	0.0	0.0	**54**
	ST/STE	0.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	**6**
	ST&E	0.0	0.0	0.0	7.2	7.2	33.6	24.0	24.0	**96**
	SE/PM	0.7	3.5	3.7	1.2	0.7	3.4	2.4	2.4	**18**
	ECO	0.8	3.8	4.1	1.4	0.8	3.7	2.6	2.6	**20**
	ILS/Spares/Govt. Supt.	2.0	3.1	49.0	39.8	8.2	0.0	0.0	0.0	**102**
S (SLEP ONLY)	**TOTAL**	10.9	45.0	94.0	54.7	16.9	40.7	29.0	29.0	**320**
	Design & Eng. SLEP	7.4	9.8	4.9	2.5	0.0	0.0	0.0	0.0	**25**
	Design & Eng. Engines	12.3	16.4	8.2	4.1	0.0	0.0	0.0	0.0	**41**
	Design & Eng. Blades	16.2	21.6	10.8	5.4	0.0	0.0	0.0	0.0	**54**
	Design & Eng. EMRH	24.3	32.4	16.2	8.1	0.0	0.0	0.0	0.0	**81**
	Design & Eng. Hook Sys	1.9	2.6	1.3	0.6	0.0	0.0	0.0	0.0	**6**
	Design & Eng. Cockpit	13.5	18.0	9.0	4.5	0.0	0.0	0.0	0.0	**45**
	Design & Eng. Avi. S/W	6.6	6.6	6.6	3.3	3.3	3.3	3.3	0.0	**33**
	FTA	0.0	41.7	71.5	6.0	0.0	0.0	0.0	0.0	**119**
	ST/STE	0.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	**6**
	ST&E	0.0	0.0	0.0	7.2	7.2	33.6	24.0	24.0	**96**
	SE/PM	8.2	15.5	12.9	4.2	1.1	3.7	2.7	2.4	**51**
	ECO	9.0	17.1	14.1	4.6	1.2	4.1	3.0	2.6	**56**
	ILS/Spares/Govt. Supt.	2.0	3.1	49.0	39.8	8.2	0.0	0.0	0.0	**102**
ALL SIX ELEMENTS	**TOTAL**	101.5	190.8	204.5	90.2	20.9	44.6	33.0	29.0	**715**
	Design & Eng. SLEP	7.4	9.8	4.9	2.5	0.0	0.0	0.0	0.0	**25**
	Design & Eng. Engines	12.3	16.4	8.2	4.1	0.0	0.0	0.0	0.0	**41**
	Design & Eng. Hook Sys	1.9	2.6	1.3	0.6	0.0	0.0	0.0	0.0	**6**
	FTA	0.0	28.3	48.4	4.0	0.0	0.0	0.0	0.0	**81**
	ST/STE	0.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	**6**
	ST&E	0.0	0.0	0.0	7.2	7.2	33.6	24.0	24.0	**96**
	SE/PM	2.2	6.3	6.3	1.8	0.7	3.4	2.4	2.4	**25**
	ECO	2.4	6.9	6.9	2.0	0.8	3.7	2.6	2.6	**28**
	ILS/Spares/Govt. Supt.	2.0	3.1	49.0	39.8	8.2	0.0	0.0	0.0	**102**
S,E,H	**TOTAL**	28.2	79.4	125.0	62.1	16.9	40.7	29.0	29.0	**410**
	Design & Eng. SLEP	7.4	9.8	4.9	2.5	0.0	0.0	0.0	0.0	**25**
	Design & Eng. Engines	12.3	16.4	8.2	4.1	0.0	0.0	0.0	0.0	**41**
	Design & Eng. Blades	16.2	21.6	10.8	5.4	0.0	0.0	0.0	0.0	**54**
	Design & Eng. Hook Sys	1.9	2.6	1.3	0.6	0.0	0.0	0.0	0.0	**6**
	FTA	0.0	33.5	57.3	4.8	0.0	0.0	0.0	0.0	**96**
	ST/STE	0.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	**6**
	ST&E	0.0	0.0	0.0	7.2	7.2	33.6	24.0	24.0	**96**
	SE/PM	3.8	9.0	8.3	2.5	0.7	3.4	2.4	2.4	**32**
	ECO	4.2	9.9	9.1	2.7	0.8	3.7	2.6	2.6	**36**
	ILS/Spares/Govt. Supt.	2.0	3.1	49.0	39.8	8.2	0.0	0.0	0.0	**102**
S,E,B,H	**TOTAL**	47.8	111.8	148.8	69.5	16.9	40.7	29.0	29.0	**494**
	Design & Eng. SLEP	7.4	9.8	4.9	2.5	0.0	0.0	0.0	0.0	**25**
	Design & Eng. Engines	12.3	16.4	8.2	4.1	0.0	0.0	0.0	0.0	**41**
	Design & Eng. Blades	16.2	21.6	10.8	5.4	0.0	0.0	0.0	0.0	**54**
	Design & Eng. EMRH	24.3	32.4	16.2	8.1	0.0	0.0	0.0	0.0	**81**
	Design & Eng. Hook Sys	1.9	2.6	1.3	0.6	0.0	0.0	0.0	0.0	**6**
	FTA	0.0	38.2	65.5	5.5	0.0	0.0	0.0	0.0	**109**
	ST/STE	0.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	**6**
	ST&E	0.0	0.0	0.0	7.2	7.2	33.6	24.0	24.0	**96**
	SE/PM	6.2	12.7	10.7	3.3	0.7	3.4	2.4	2.4	**42**
	ECO	6.8	14.0	11.8	3.7	0.8	3.7	2.6	2.6	**46**
	ILS/Spares/Govt. Supt.	2.0	3.1	49.0	39.8	8.2	0.0	0.0	0.0	**102**
S,E,B,R,H	**TOTAL**	77.2	156.8	178.4	80.1	16.9	40.7	29.0	29.0	**608**
	Design & Eng. SLEP	7.4	9.8	4.9	2.5	0.0	0.0	0.0	0.0	**25**
	Design & Eng. Blades	16.2	21.6	10.8	5.4	0.0	0.0	0.0	0.0	**54**
	FTA	0.0	24.1	41.2	3.4	0.0	0.0	0.0	0.0	**69**
	ST/STE	0.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	**6**
	ST&E	0.0	0.0	0.0	7.2	7.2	33.6	24.0	24.0	**96**
	SE/PM	2.4	6.1	5.7	1.8	0.7	3.4	2.4	2.4	**25**
	ECO	2.6	6.8	6.3	2.0	0.8	3.7	2.6	2.6	**27**
	ILS/Spares/Govt. Supt.	2.0	3.1	49.0	39.8	8.2	0.0	0.0	0.0	**102**
S,B	**TOTAL**	30.5	77.4	117.9	62.2	16.9	40.7	29.0	29.0	**404**

	Design & Eng. SLEP	7.4	9.8	4.9	2.5	0.0	0.0	0.0	0.0	**25**
	Design & Eng. Blades	16.2	21.6	10.8	5.4	0.0	0.0	0.0	0.0	**54**
	Design & Eng. EMRH	24.3	32.4	16.2	8.1	0.0	0.0	0.0	0.0	**81**
	FTA	0.0	28.8	49.4	4.1	0.0	0.0	0.0	0.0	**82**
	ST/STE	0.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	**6**
	ST&E	0.0	0.0	0.0	7.2	7.2	33.6	24.0	24.0	**96**
	SE/PM	4.8	9.9	8.1	2.7	0.7	3.4	2.4	2.4	**34**
	ECO	5.3	10.9	8.9	3.0	0.8	3.7	2.6	2.6	**38**
	ILS/Spares/Govt. Supt.	2.0	3.1	49.0	39.8	8.2	0.0	0.0	0.0	**102**
S,B,R	**TOTAL**	59.9	122.4	147.4	72.8	16.9	40.7	29.0	29.0	**518**
	Design & Eng. SLEP	7.4	9.8	4.9	2.5	0.0	0.0	0.0	0.0	**25**
	Design & Eng. Blades	16.2	21.6	10.8	5.4	0.0	0.0	0.0	0.0	**54**
	Design & Eng. EMRH	24.3	32.4	16.2	8.1	0.0	0.0	0.0	0.0	**81**
	Design & Eng. Cockpit	13.5	18.0	9.0	4.5	0.0	0.0	0.0	0.0	**45**
	Design & Eng. Avi. S/W	6.6	6.6	6.6	3.3	3.3	3.3	3.3	0.0	**33**
	FTA	0.0	32.3	55.4	4.6	0.0	0.0	0.0	0.0	**92**
	ST/STE	0.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	**6**
	ST&E	0.0	0.0	0.0	7.2	7.2	33.6	24.0	24.0	**96**
	SE/PM	6.8	12.7	10.3	3.6	1.1	3.7	2.7	2.4	**43**
	ECO	7.5	13.9	11.3	3.9	1.2	4.1	3.0	2.6	**48**
	ILS/Spares/Govt. Supt.	2.0	3.1	49.0	39.8	8.2	0.0	0.0	0.0	**102**
S,B,R,C	**TOTAL**	84.3	156.4	173.5	82.8	20.9	44.6	33.0	29.0	**625**
	Design & Eng. SLEP	7.4	9.8	4.9	2.5	0.0	0.0	0.0	0.0	**25**
	Design & Eng. EMRH	24.3	32.4	16.2	8.1	0.0	0.0	0.0	0.0	**81**
	FTA	0.0	23.6	40.5	3.4	0.0	0.0	0.0	0.0	**68**
	ST/STE	0.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	**6**
	ST&E	0.0	0.0	0.0	7.2	7.2	33.6	24.0	24.0	**96**
	SE/PM	3.2	7.2	6.2	2.1	0.7	3.4	2.4	2.4	**28**
	ECO	3.5	7.9	6.8	2.3	0.8	3.7	2.6	2.6	**30**
	ILS/Spares/Govt. Supt.	2.0	3.1	49.0	39.8	8.2	0.0	0.0	0.0	**102**
S,R	**TOTAL**	40.3	90.0	123.5	65.3	16.9	40.7	29.0	29.0	**435**
	Design & Eng. SLEP	7.4	9.8	4.9	2.5	0.0	0.0	0.0	0.0	**25**
	Design & Eng. EMRH	24.3	32.4	16.2	8.1	0.0	0.0	0.0	0.0	**81**
	Design & Eng. Cockpit	13.5	18.0	9.0	4.5	0.0	0.0	0.0	0.0	**45**
	Design & Eng. Avi. S/W	6.6	6.6	6.6	3.3	3.3	3.3	3.3	0.0	**33**
	FTA	0.0	27.1	46.5	3.9	0.0	0.0	0.0	0.0	**78**
	ST/STE	0.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	**6**
	ST&E	0.0	0.0	0.0	7.2	7.2	33.6	24.0	24.0	**96**
	SE/PM	5.2	10.0	8.3	2.9	1.1	3.7	2.7	2.4	**36**
	ECO	5.7	11.0	9.2	3.2	1.2	4.1	3.0	2.6	**40**
	ILS/Spares/Govt. Supt.	2.0	3.1	49.0	39.8	8.2	0.0	0.0	0.0	**102**
S,R,C	**TOTAL**	64.7	124.0	149.7	75.4	20.9	44.6	33.0	29.0	**541**

HIGH		RDT&E FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	TOTAL
	Design & Eng. SLEP	10.2	13.6	6.8	3.4	0.0	0.0	0.0	0.0	**34**
	FTA	0.0	21.1	36.1	3.0	0.0	0.0	0.0	0.0	**60**
	ST/STE	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	**7**
	ST&E	0.0	0.0	0.0	8.1	8.1	37.8	27.0	27.0	**108**
	SE/PM	1.0	4.2	4.3	1.5	0.8	3.8	2.7	2.7	**21**
	ECO	1.1	4.6	4.7	1.6	0.9	4.2	3.0	3.0	**23**
	ILS/Spares/Govt. Supt.	2.3	3.5	55.2	44.9	9.2	0.0	0.0	0.0	**115**
S (SLEP ONLY)	**TOTAL**	14.6	53.9	107.2	62.4	19.0	45.7	32.7	32.7	**368**
	Design & Eng. SLEP	10.2	13.6	6.8	3.4	0.0	0.0	0.0	0.0	**34**
	Design & Eng. Engines	12.9	17.2	8.6	4.3	0.0	0.0	0.0	0.0	**43**
	Design & Eng. Blades	18.0	24.0	12.0	6.0	0.0	0.0	0.0	0.0	**60**
	Design & Eng. EMRH	27.0	36.0	18.0	9.0	0.0	0.0	0.0	0.0	**90**
	Design & Eng. Hook Sys	2.7	3.6	1.8	0.9	0.0	0.0	0.0	0.0	**9**
	Design & Eng. Cockpit	15.0	20.0	10.0	5.0	0.0	0.0	0.0	0.0	**50**
	Design & Eng. Avi. S/W	8.8	8.8	8.8	4.4	4.4	4.4	4.4	0.0	**44**
	FTA	0.0	48.2	82.6	6.9	0.0	0.0	0.0	0.0	**138**
	ST/STE	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	**7**
	ST&E	0.0	0.0	0.0	8.1	8.1	37.8	27.0	27.0	**108**
	SE/PM	9.5	17.8	14.9	4.8	1.3	4.2	3.1	2.7	**58**
	ECO	10.4	19.6	16.3	5.3	1.4	4.6	3.5	3.0	**64**
	ILS/Spares/Govt. Supt.	2.3	3.5	55.2	44.9	9.2	0.0	0.0	0.0	**115**
ALL SIX ELEMENTS	**TOTAL**	116.8	219.3	235.0	102.9	24.3	51.1	38.0	32.7	**820**
	Design & Eng. SLEP	10.2	13.6	6.8	3.4	0.0	0.0	0.0	0.0	**34**
	Design & Eng. Engines	12.9	17.2	8.6	4.3	0.0	0.0	0.0	0.0	**43**
	Design & Eng. Hook Sys	2.7	3.6	1.8	0.9	0.0	0.0	0.0	0.0	**9**
	FTA	0.0	30.8	52.7	4.4	0.0	0.0	0.0	0.0	**88**
	ST/STE	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	**7**
	ST&E	0.0	0.0	0.0	8.1	8.1	37.8	27.0	27.0	**108**
	SE/PM	2.6	7.2	7.0	2.1	0.8	3.8	2.7	2.7	**29**
	ECO	2.8	7.9	7.7	2.3	0.9	4.2	3.0	3.0	**32**
	ILS/Spares/Govt. Supt.	2.3	3.5	55.2	44.9	9.2	0.0	0.0	0.0	**115**
S,E,H	**TOTAL**	33.5	90.8	139.8	70.4	19.0	45.7	32.7	32.7	**465**
	Design & Eng. SLEP	10.2	13.6	6.8	3.4	0.0	0.0	0.0	0.0	**34**
	Design & Eng. Engines	12.9	17.2	8.6	4.3	0.0	0.0	0.0	0.0	**43**
	Design & Eng. Blades	18.0	24.0	12.0	6.0	0.0	0.0	0.0	0.0	**60**
	Design & Eng. Hook Sys	2.7	3.6	1.8	0.9	0.0	0.0	0.0	0.0	**9**
	FTA	0.0	39.3	67.4	5.6	0.0	0.0	0.0	0.0	**112**
	ST/STE	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	**7**
	ST&E	0.0	0.0	0.0	8.1	8.1	37.8	27.0	27.0	**108**
	SE/PM	4.4	10.5	9.7	2.8	0.8	3.8	2.7	2.7	**37**
	ECO	4.8	11.5	10.6	3.1	0.9	4.2	3.0	3.0	**41**
	ILS/Spares/Govt. Supt.	2.3	3.5	55.2	44.9	9.2	0.0	0.0	0.0	**115**
S,E,B,H	**TOTAL**	55.3	130.2	172.1	79.1	19.0	45.7	32.7	32.7	**567**
	Design & Eng. SLEP	10.2	13.6	6.8	3.4	0.0	0.0	0.0	0.0	**34**
	Design & Eng. Engines	12.9	17.2	8.6	4.3	0.0	0.0	0.0	0.0	**43**
	Design & Eng. Blades	18.0	24.0	12.0	6.0	0.0	0.0	0.0	0.0	**60**
	Design & Eng. EMRH	27.0	36.0	18.0	9.0	0.0	0.0	0.0	0.0	**90**
	Design & Eng. Hook Sys	2.7	3.6	1.8	0.9	0.0	0.0	0.0	0.0	**9**
	FTA	0.0	44.7	76.6	6.4	0.0	0.0	0.0	0.0	**128**
	ST/STE	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	**7**
	ST&E	0.0	0.0	0.0	8.1	8.1	37.8	27.0	27.0	**108**
	SE/PM	7.1	14.6	12.4	3.8	0.8	3.8	2.7	2.7	**48**
	ECO	7.8	16.1	13.6	4.2	0.9	4.2	3.0	3.0	**53**
	ILS/Spares/Govt. Supt.	2.3	3.5	55.2	44.9	9.2	0.0	0.0	0.0	**115**
S,E,B,R,H	**TOTAL**	88.0	180.2	204.9	90.9	19.0	45.7	32.7	32.7	**694**
	Design & Eng. SLEP	10.2	13.6	6.8	3.4	0.0	0.0	0.0	0.0	**34**
	Design & Eng. Blades	18.0	24.0	12.0	6.0	0.0	0.0	0.0	0.0	**60**
	FTA	0.0	29.6	50.8	4.2	0.0	0.0	0.0	0.0	**85**
	ST/STE	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	**7**
	ST&E	0.0	0.0	0.0	8.1	8.1	37.8	27.0	27.0	**108**
	SE/PM	2.8	7.4	7.0	2.2	0.8	3.8	2.7	2.7	**29**
	ECO	3.1	8.2	7.7	2.4	0.9	4.2	3.0	3.0	**32**
	ILS/Spares/Govt. Supt.	2.3	3.5	55.2	44.9	9.2	0.0	0.0	0.0	**115**
S,B	**TOTAL**	36.4	93.3	139.4	71.1	19.0	45.7	32.7	32.7	**470**

	Design & Eng. SLEP	10.2	13.6	6.8	3.4	0.0	0.0	0.0	0.0	**34**
	Design & Eng. Blades	18.0	24.0	12.0	6.0	0.0	0.0	0.0	0.0	**60**
	Design & Eng. EMRH	27.0	36.0	18.0	9.0	0.0	0.0	0.0	0.0	**90**
	FTA	0.0	35.0	60.0	5.0	0.0	0.0	0.0	0.0	**100**
	ST/STE	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	**7**
	ST&E	0.0	0.0	0.0	8.1	8.1	37.8	27.0	27.0	**108**
	SE/PM	5.5	11.6	9.7	3.1	0.8	3.8	2.7	2.7	**40**
	ECO	6.1	12.7	10.6	3.5	0.9	4.2	3.0	3.0	**44**
	ILS/Spares/Govt. Supt.	2.3	3.5	55.2	44.9	9.2	0.0	0.0	0.0	**115**
S,B,R	**TOTAL**	69.1	143.3	172.3	83.0	19.0	45.7	32.7	32.7	**598**
	Design & Eng. SLEP	10.2	13.6	6.8	3.4	0.0	0.0	0.0	0.0	**34**
	Design & Eng. Blades	18.0	24.0	12.0	6.0	0.0	0.0	0.0	0.0	**60**
	Design & Eng. EMRH	27.0	36.0	18.0	9.0	0.0	0.0	0.0	0.0	**90**
	Design & Eng. Cockpit	15.0	20.0	10.0	5.0	0.0	0.0	0.0	0.0	**50**
	Design & Eng. Avi. S/W	8.8	8.8	8.8	4.4	4.4	4.4	4.4	0.0	**44**
	FTA	0.0	38.5	66.0	5.5	0.0	0.0	0.0	0.0	**110**
	ST/STE	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	**7**
	ST&E	0.0	0.0	0.0	8.1	8.1	37.8	27.0	27.0	**108**
	SE/PM	7.9	14.8	12.2	4.1	1.3	4.2	3.1	2.7	**50**
	ECO	8.7	16.3	13.4	4.6	1.4	4.6	3.5	3.0	**55**
	ILS/Spares/Govt. Supt.	2.3	3.5	55.2	44.9	9.2	0.0	0.0	0.0	**115**
S,B,R,C	**TOTAL**	97.9	182.4	202.3	94.9	24.3	51.1	38.0	32.7	**724**
	Design & Eng. SLEP	10.2	13.6	6.8	3.4	0.0	0.0	0.0	0.0	**34**
	Design & Eng. EMRH	27.0	36.0	18.0	9.0	0.0	0.0	0.0	0.0	**90**
	FTA	0.0	26.4	45.3	3.8	0.0	0.0	0.0	0.0	**75**
	ST/STE	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	**7**
	ST&E	0.0	0.0	0.0	8.1	8.1	37.8	27.0	27.0	**108**
	SE/PM	3.7	8.3	7.0	2.4	0.8	3.8	2.7	2.7	**31**
	ECO	4.1	9.1	7.7	2.7	0.9	4.2	3.0	3.0	**35**
	ILS/Spares/Govt. Supt.	2.3	3.5	55.2	44.9	9.2	0.0	0.0	0.0	**115**
S,R	**TOTAL**	47.3	103.9	140.0	74.2	19.0	45.7	32.7	32.7	**496**
	Design & Eng. SLEP	10.2	13.6	6.8	3.4	0.0	0.0	0.0	0.0	**34**
	Design & Eng. EMRH	27.0	36.0	18.0	9.0	0.0	0.0	0.0	0.0	**90**
	Design & Eng. Cockpit	15.0	20.0	10.0	5.0	0.0	0.0	0.0	0.0	**50**
	Design & Eng. Avi. S/W	8.8	8.8	8.8	4.4	4.4	4.4	4.4	0.0	**44**
	FTA	0.0	29.9	51.3	4.3	0.0	0.0	0.0	0.0	**85**
	ST/STE	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	**7**
	ST&E	0.0	0.0	0.0	8.1	8.1	37.8	27.0	27.0	**108**
	SE/PM	6.1	11.5	9.5	3.4	1.3	4.2	3.1	2.7	**42**
	ECO	6.7	12.7	10.4	3.8	1.4	4.6	3.5	3.0	**46**
	ILS/Spares/Govt. Supt.	2.3	3.5	55.2	44.9	9.2	0.0	0.0	0.0	**115**
S,R,C	**TOTAL**	76.1	143.0	170.0	86.2	24.3	51.1	38.0	32.7	**621**

LOW		APN										
		FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	TOTAL
	SLEP & Hook Sys. Fab Kit	33.8	46.9	89.8	109.6	108.8	109.0	109.7	110.8	104.7	0.0	**823**
	IDIA&T	0.0	27.1	37.5	71.8	87.3	86.5	86.6	87.1	88.0	83.1	**655**
	ST/STE	24.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**30**
	SE/PM	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	**37**
	ECO	0.8	1.6	2.6	3.7	4.0	4.0	4.0	4.0	3.9	1.7	**30**
	ILS/Spares/Govt. Supt.	77.3	72.1	56.7	51.5	51.5	51.5	51.5	51.5	51.5	0.0	**515**
S (SLEP ONLY)	**TOTAL**	139.5	157.3	190.2	240.2	255.3	254.7	255.5	257.1	251.8	88.5	**2,090**
	SLEP & Hook Sys. Fab Kit	33.8	46.9	89.8	109.6	108.8	109.0	109.7	110.8	104.7	0.0	**823**
	Engines Fab Kit	19.8	29.6	59.1	73.8	73.8	73.8	73.7	73.7	68.8	0.0	**546**
	Blades Fab Kit	14.8	17.2	28.8	32.2	30.2	28.9	27.9	27.2	24.9	0.0	**232**
	EMRH Fab Kit	13.7	18.2	32.5	38.2	37.1	36.3	35.7	35.2	32.7	0.0	**280**
	Cockpit Fab Kit	10.0	15.0	30.0	37.5	37.5	37.5	37.5	37.5	35.0	0.0	**278**
	IDIA&T	0.0	27.1	37.5	71.8	87.3	86.5	86.6	87.1	88.0	83.1	**655**
	ST/STE	24.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**30**
	SE/PM	7.7	9.3	14.2	16.4	16.2	16.0	15.9	15.8	15.0	3.7	**130**
	ECO	2.0	3.3	5.8	7.6	7.8	7.8	7.7	7.7	7.4	1.7	**59**
	ILS/Spares/Govt. Supt.	77.3	72.1	56.7	51.5	51.5	51.5	51.5	51.5	51.5	0.0	**515**
ALL SIX ELEMENTS	**TOTAL**	203.1	244.6	354.4	438.6	450.3	447.3	446.4	446.6	427.9	88.5	**3,548**
	SLEP & Hook Sys. Fab Kit	33.8	46.9	89.8	109.6	108.8	109.0	109.7	110.8	104.7	0.0	**823**
	Engines Fab Kit	19.8	29.6	59.1	73.8	73.8	73.8	73.7	73.7	68.8	0.0	**546**
	IDIA&T	0.0	27.1	37.5	71.8	87.3	86.5	86.6	87.1	88.0	83.1	**655**
	ST/STE	24.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**30**
	SE/PM	5.1	5.7	7.8	8.8	8.8	8.8	8.8	8.8	8.5	3.7	**75**
	ECO	1.2	2.2	3.9	5.3	5.6	5.6	5.6	5.6	5.4	1.7	**42**
	ILS/Spares/Govt. Supt.	77.3	72.1	56.7	51.5	51.5	51.5	51.5	51.5	51.5	0.0	**515**
S,E,H	**TOTAL**	161.1	189.6	254.7	320.8	335.8	335.2	336.0	337.6	326.9	88.5	**2,686**
	SLEP & Hook Sys. Fab Kit	33.8	46.9	89.8	109.6	108.8	109.0	109.7	110.8	104.7	0.0	**823**
	Engines Fab Kit	19.8	29.6	59.1	73.8	73.8	73.8	73.7	73.7	68.8	0.0	**546**
	Blades Fab Kit	14.8	17.2	28.8	32.2	30.2	28.9	27.9	27.2	24.9	0.0	**232**
	IDIA&T	0.0	27.1	37.5	71.8	87.3	86.5	86.6	87.1	88.0	83.1	**655**
	ST/STE	24.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**30**
	SE/PM	6.1	6.9	9.8	11.1	11.0	10.9	10.8	10.7	10.2	3.7	**91**
	ECO	1.5	2.6	4.5	6.0	6.2	6.2	6.2	6.2	5.9	1.7	**47**
	ILS/Spares/Govt. Supt.	77.3	72.1	56.7	51.5	51.5	51.5	51.5	51.5	51.5	0.0	**515**
S,E,B,H	**TOTAL**	177.3	208.4	286.2	355.9	368.8	366.7	366.5	367.2	354.1	88.5	**2,940**
	SLEP & Hook Sys. Fab Kit	33.8	46.9	89.8	109.6	108.8	109.0	109.7	110.8	104.7	0.0	**823**
	Engines Fab Kit	19.8	29.6	59.1	73.8	73.8	73.8	73.7	73.7	68.8	0.0	**546**
	Blades Fab Kit	14.8	17.2	28.8	32.2	30.2	28.9	27.9	27.2	24.9	0.0	**232**
	EMRH Fab Kit	13.7	18.2	32.5	38.2	37.1	36.3	35.7	35.2	32.7	0.0	**280**
	IDIA&T	0.0	27.1	37.5	71.8	87.3	86.5	86.6	87.1	88.0	83.1	**655**
	ST/STE	24.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**30**
	SE/PM	7.0	8.2	12.1	13.8	13.5	13.4	13.3	13.2	12.5	3.7	**111**
	ECO	1.8	2.9	5.2	6.8	7.0	7.0	6.9	6.9	6.6	1.7	**53**
	ILS/Spares/Govt. Supt.	77.3	72.1	56.7	51.5	51.5	51.5	51.5	51.5	51.5	0.0	**515**
S,E,B,R,H	**TOTAL**	192.2	228.2	321.7	397.7	409.3	406.4	405.4	405.7	389.7	88.5	**3,245**
	SLEP & Hook Sys. Fab Kit	33.8	46.9	89.8	109.6	108.8	109.0	109.7	110.8	104.7	0.0	**823**
	Blades Fab Kit	14.8	17.2	28.8	32.2	30.2	28.9	27.9	27.2	24.9	0.0	**232**
	IDIA&T	0.0	27.1	37.5	71.8	87.3	86.5	86.6	87.1	88.0	83.1	**655**
	ST/STE	24.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**30**
	SE/PM	4.7	4.9	5.7	5.9	5.8	5.7	5.6	5.6	5.4	3.7	**53**
	ECO	1.1	1.9	3.2	4.4	4.6	4.6	4.6	4.6	4.5	1.7	**35**
	ILS/Spares/Govt. Supt.	77.3	72.1	56.7	51.5	51.5	51.5	51.5	51.5	51.5	0.0	**515**
S,B	**TOTAL**	155.7	176.1	221.6	275.4	288.3	286.2	286.0	286.8	279.0	88.5	**2,344**
	SLEP & Hook Sys. Fab Kit	33.8	46.9	89.8	109.6	108.8	109.0	109.7	110.8	104.7	0.0	**823**
	Blades Fab Kit	14.8	17.2	28.8	32.2	30.2	28.9	27.9	27.2	24.9	0.0	**232**
	EMRH Fab Kit	13.7	18.2	32.5	38.2	37.1	36.3	35.7	35.2	32.7	0.0	**280**
	IDIA&T	0.0	27.1	37.5	71.8	87.3	86.5	86.6	87.1	88.0	83.1	**655**
	ST/STE	24.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**30**
	SE/PM	5.7	6.1	8.0	8.6	8.4	8.2	8.1	8.0	7.7	3.7	**73**
	ECO	1.4	2.3	3.9	5.2	5.4	5.4	5.4	5.4	5.2	1.7	**41**
	ILS/Spares/Govt. Supt.	77.3	72.1	56.7	51.5	51.5	51.5	51.5	51.5	51.5	0.0	**515**
S,B,R	**TOTAL**	170.6	195.9	257.2	317.1	328.8	325.9	325.0	325.2	314.7	88.5	**2,649**

	SLEP & Hook Sys. Fab Kit	33.8	46.9	89.8	109.6	108.8	109.0	109.7	110.8	104.7	0.0	**823**
	Blades Fab Kit	14.8	17.2	28.8	32.2	30.2	28.9	27.9	27.2	24.9	0.0	**232**
	EMRH Fab Kit	13.7	18.2	32.5	38.2	37.1	36.3	35.7	35.2	32.7	0.0	**280**
	Cockpit Fab Kit	10.0	15.0	30.0	37.5	37.5	37.5	37.5	37.5	35.0	0.0	**278**
	IDIA&T	0.0	27.1	37.5	71.8	87.3	86.5	86.6	87.1	88.0	83.1	**655**
	ST/STE	24.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**30**
	SE/PM	6.4	7.2	10.1	11.2	11.0	10.9	10.8	10.7	10.2	3.7	**92**
	ECO	1.6	2.6	4.6	6.0	6.2	6.2	6.2	6.2	5.9	1.7	**47**
	ILS/Spares/Govt. Supt.	77.3	72.1	56.7	51.5	51.5	51.5	51.5	51.5	51.5	0.0	**515**
S,B,R,C	**TOTAL**	181.5	212.3	289.9	358.0	369.7	366.8	365.9	366.2	352.9	88.5	**2,952**
	SLEP & Hook Sys. Fab Kit	33.8	46.9	89.8	109.6	108.8	109.0	109.7	110.8	104.7	0.0	**823**
	EMRH Fab Kit	13.7	18.2	32.5	38.2	37.1	36.3	35.7	35.2	32.7	0.0	**280**
	IDIA&T	0.0	27.1	37.5	71.8	87.3	86.5	86.6	87.1	88.0	83.1	**655**
	ST/STE	24.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**30**
	SE/PM	4.6	4.9	5.9	6.3	6.3	6.2	6.2	6.1	6.0	3.7	**56**
	ECO	1.0	1.9	3.3	4.5	4.8	4.8	4.8	4.8	4.6	1.7	**36**
	ILS/Spares/Govt. Supt.	77.3	72.1	56.7	51.5	51.5	51.5	51.5	51.5	51.5	0.0	**515**
S,R	**TOTAL**	154.4	177.2	225.7	281.9	295.8	294.3	294.5	295.6	287.5	88.5	**2,395**
	SLEP & Hook Sys. Fab Kit	33.8	46.9	89.8	109.6	108.8	109.0	109.7	110.8	104.7	0.0	**823**
	EMRH Fab Kit	13.7	18.2	32.5	38.2	37.1	36.3	35.7	35.2	32.7	0.0	**280**
	Cockpit Fab Kit	10.0	15.0	30.0	37.5	37.5	37.5	37.5	37.5	35.0	0.0	**278**
	IDIA&T	0.0	27.1	37.5	71.8	87.3	86.5	86.6	87.1	88.0	83.1	**655**
	ST/STE	24.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**30**
	SE/PM	5.3	6.0	8.0	9.0	8.9	8.8	8.8	8.8	8.4	3.7	**76**
	ECO	1.3	2.3	4.0	5.3	5.6	5.6	5.6	5.6	5.4	1.7	**42**
	ILS/Spares/Govt. Supt.	77.3	72.1	56.7	51.5	51.5	51.5	51.5	51.5	51.5	0.0	**515**
S,R,C	**TOTAL**	165.3	193.5	258.5	322.9	336.7	335.2	335.4	336.5	325.7	88.5	**2,698**

HIGH	**APN**											
		FY09	**FY10**	**FY11**	**FY12**	**FY13**	**FY14**	**FY15**	**FY16**	**FY17**	**FY18**	**TOTAL**
	SLEP & Hook Sys. Fab Kit	37.8	52.4	100.4	122.5	121.6	121.8	122.7	123.9	117.1	0.0	**920**
	IDIA&T	0.0	30.3	41.9	80.2	97.6	96.7	96.8	97.4	98.3	92.9	**732**
	ST/STE	24.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**30**
	SE/PM	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	**37**
	ECO	0.8	1.7	2.9	4.1	4.5	4.4	4.5	4.5	4.4	1.9	**34**
	ILS/Spares/Govt. Supt.	77.3	72.1	56.7	51.5	51.5	51.5	51.5	51.5	51.5	0.0	**515**
S (SLEP ONLY)	**TOTAL**	143.6	166.2	205.5	262.0	278.9	278.2	279.1	280.9	274.9	98.5	**2,268**
	SLEP & Hook Sys. Fab Kit	37.8	52.4	100.4	122.5	121.6	121.8	122.7	123.9	117.1	0.0	**920**
	Engines Fab Kit	19.8	29.6	59.1	73.8	73.8	73.8	73.7	73.7	68.8	0.0	**546**
	Blades Fab Kit	24.4	29.4	49.3	55.2	51.7	49.5	47.8	46.4	42.6	0.0	**396**
	EMRH Fab Kit	15.3	20.3	36.4	42.7	41.5	40.6	39.9	39.4	36.5	0.0	**313**
	Cockpit Fab Kit	10.0	15.0	30.0	37.5	37.5	37.5	37.5	37.5	35.0	0.0	**278**
	IDIA&T	0.0	30.3	41.9	80.2	97.6	96.7	96.8	97.4	98.3	92.9	**732**
	ST/STE	24.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**30**
	SE/PM	8.5	10.3	15.9	18.3	18.0	17.8	17.6	17.5	16.5	3.7	**144**
	ECO	2.3	3.7	6.7	8.6	8.8	8.8	8.7	8.7	8.3	1.9	**67**
	ILS/Spares/Govt. Supt.	77.3	72.1	56.7	51.5	51.5	51.5	51.5	51.5	51.5	0.0	**515**
ALL SIX ELEMENTS	**TOTAL**	219.4	269.1	396.3	490.4	502.1	497.9	496.2	496.0	474.5	98.5	**3,940**
	SLEP & Hook Sys. Fab Kit	37.8	52.4	100.4	122.5	121.6	121.8	122.7	123.9	117.1	0.0	**920**
	Engines Fab Kit	19.8	29.6	59.1	73.8	73.8	73.8	73.7	73.7	68.8	0.0	**546**
	IDIA&T	0.0	30.3	41.9	80.2	97.6	96.7	96.8	97.4	98.3	92.9	**732**
	ST/STE	24.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**30**
	SE/PM	5.1	5.7	7.8	8.8	8.8	8.8	8.8	8.8	8.5	3.7	**75**
	ECO	1.3	2.4	4.2	5.7	6.0	6.0	6.0	6.1	5.9	1.9	**45**
	ILS/Spares/Govt. Supt.	77.3	72.1	56.7	51.5	51.5	51.5	51.5	51.5	51.5	0.0	**515**
S,E,H	**TOTAL**	165.1	198.5	270.0	342.6	359.4	358.7	359.6	361.4	350.0	98.5	**2,864**
	SLEP & Hook Sys. Fab Kit	37.8	52.4	100.4	122.5	121.6	121.8	122.7	123.9	117.1	0.0	**920**
	Engines Fab Kit	19.8	29.6	59.1	73.8	73.8	73.8	73.7	73.7	68.8	0.0	**546**
	Blades Fab Kit	24.4	29.4	49.3	55.2	51.7	49.5	47.8	46.4	42.6	0.0	**396**
	IDIA&T	0.0	30.3	41.9	80.2	97.6	96.7	96.8	97.4	98.3	92.9	**732**
	ST/STE	24.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**30**
	SE/PM	6.8	7.8	11.3	12.7	12.5	12.3	12.2	12.1	11.5	3.7	**103**
	ECO	1.8	3.0	5.2	6.9	7.1	7.1	7.1	7.1	6.8	1.9	**54**
	ILS/Spares/Govt. Supt.	77.3	72.1	56.7	51.5	51.5	51.5	51.5	51.5	51.5	0.0	**515**
S,E,B,H	**TOTAL**	191.8	230.6	323.9	402.8	415.9	412.7	411.7	412.0	396.5	98.5	**3,296**
	SLEP & Hook Sys. Fab Kit	37.8	52.4	100.4	122.5	121.6	121.8	122.7	123.9	117.1	0.0	**920**
	Engines Fab Kit	19.8	29.6	59.1	73.8	73.8	73.8	73.7	73.7	68.8	0.0	**546**
	Blades Fab Kit	24.4	29.4	49.3	55.2	51.7	49.5	47.8	46.4	42.6	0.0	**396**
	EMRH Fab Kit	15.3	20.3	36.4	42.7	41.5	40.6	39.9	39.4	36.5	0.0	**313**
	IDIA&T	0.0	30.3	41.9	80.2	97.6	96.7	96.8	97.4	98.3	92.9	**732**
	ST/STE	24.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**30**
	SE/PM	7.8	9.2	13.8	15.7	15.4	15.1	15.0	14.8	14.0	3.7	**125**
	ECO	2.1	3.4	6.0	7.8	8.0	7.9	7.9	7.9	7.5	1.9	**61**
	ILS/Spares/Govt. Supt.	77.3	72.1	56.7	51.5	51.5	51.5	51.5	51.5	51.5	0.0	**515**
S,E,B,R,H	**TOTAL**	208.4	252.8	363.6	449.4	461.1	456.9	455.3	455.0	436.3	98.5	**3,637**
	SLEP & Hook Sys. Fab Kit	37.8	52.4	100.4	122.5	121.6	121.8	122.7	123.9	117.1	0.0	**920**
	Blades Fab Kit	24.4	29.4	49.3	55.2	51.7	49.5	47.8	46.4	42.6	0.0	**396**
	IDIA&T	0.0	30.3	41.9	80.2	97.6	96.7	96.8	97.4	98.3	92.9	**732**
	ST/STE	24.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**30**
	SE/PM	5.4	5.7	7.1	7.5	7.3	7.1	7.0	6.9	6.7	3.7	**64**
	ECO	1.4	2.4	4.0	5.3	5.6	5.5	5.5	5.5	5.3	1.9	**42**
	ILS/Spares/Govt. Supt.	77.3	72.1	56.7	51.5	51.5	51.5	51.5	51.5	51.5	0.0	**515**
S,B	**TOTAL**	170.2	198.3	259.3	322.2	335.3	332.2	331.2	331.6	321.4	98.5	**2,700**

	SLEP & Hook Sys. Fab Kit	37.8	52.4	100.4	122.5	121.6	121.8	122.7	123.9	117.1	0.0	**920**
	Blades Fab Kit	24.4	29.4	49.3	55.2	51.7	49.5	47.8	46.4	42.6	0.0	**396**
	EMRH Fab Kit	15.3	20.3	36.4	42.7	41.5	40.6	39.9	39.4	36.5	0.0	**313**
	IDIA&T	0.0	30.3	41.9	80.2	97.6	96.7	96.8	97.4	98.3	92.9	**732**
	ST/STE	24.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**30**
	SE/PM	6.4	7.1	9.7	10.5	10.2	10.0	9.8	9.7	9.2	3.7	**86**
	ECO	1.7	2.8	4.8	6.2	6.5	6.4	6.3	6.3	6.1	1.9	**49**
	ILS/Spares/Govt. Supt.	77.3	72.1	56.7	51.5	51.5	51.5	51.5	51.5	51.5	0.0	**515**
S,B,R	**TOTAL**	186.9	220.5	299.0	368.8	380.6	376.4	374.8	374.6	361.3	98.5	**3,041**
	SLEP & Hook Sys. Fab Kit	37.8	52.4	100.4	122.5	121.6	121.8	122.7	123.9	117.1	0.0	**920**
	Blades Fab Kit	24.4	29.4	49.3	55.2	51.7	49.5	47.8	46.4	42.6	0.0	**396**
	EMRH Fab Kit	15.3	20.3	36.4	42.7	41.5	40.6	39.9	39.4	36.5	0.0	**313**
	Cockpit Fab Kit	10.0	15.0	30.0	37.5	37.5	37.5	37.5	37.5	35.0	0.0	**278**
	IDIA&T	0.0	30.3	41.9	80.2	97.6	96.7	96.8	97.4	98.3	92.9	**732**
	ST/STE	24.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**30**
	SE/PM	7.1	8.2	11.8	13.1	12.8	12.6	12.4	12.3	11.7	3.7	**106**
	ECO	1.9	3.1	5.4	7.0	7.3	7.2	7.1	7.1	6.8	1.9	**55**
	ILS/Spares/Govt. Supt.	77.3	72.1	56.7	51.5	51.5	51.5	51.5	51.5	51.5	0.0	**515**
S,B,R,C	**TOTAL**	197.8	236.8	331.8	409.8	421.5	417.4	415.7	415.5	399.5	98.5	**3,344**
	SLEP & Hook Sys. Fab Kit	37.8	52.4	100.4	122.5	121.6	121.8	122.7	123.9	117.1	0.0	**920**
	EMRH Fab Kit	15.3	20.3	36.4	42.7	41.5	40.6	39.9	39.4	36.5	0.0	**313**
	IDIA&T	0.0	30.3	41.9	80.2	97.6	96.7	96.8	97.4	98.3	92.9	**732**
	ST/STE	24.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**30**
	SE/PM	4.7	5.1	6.2	6.7	6.6	6.5	6.5	6.4	6.2	3.7	**59**
	ECO	1.2	2.2	3.7	5.0	5.3	5.3	5.3	5.3	5.2	1.9	**40**
	ILS/Spares/Govt. Supt.	77.3	72.1	56.7	51.5	51.5	51.5	51.5	51.5	51.5	0.0	**515**
S,R	**TOTAL**	160.2	188.4	245.2	308.6	324.1	322.5	322.6	323.9	314.8	98.5	**2,609**
	SLEP & Hook Sys. Fab Kit	37.8	52.4	100.4	122.5	121.6	121.8	122.7	123.9	117.1	0.0	**920**
	EMRH Fab Kit	15.3	20.3	36.4	42.7	41.5	40.6	39.9	39.4	36.5	0.0	**313**
	Cockpit Fab Kit	10.0	15.0	30.0	37.5	37.5	37.5	37.5	37.5	35.0	0.0	**278**
	IDIA&T	0.0	30.3	41.9	80.2	97.6	96.7	96.8	97.4	98.3	92.9	**732**
	ST/STE	24.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**30**
	SE/PM	5.4	6.1	8.3	9.3	9.2	9.1	9.1	9.1	8.7	3.7	**78**
	ECO	1.4	2.5	4.3	5.8	6.1	6.1	6.1	6.1	5.9	1.9	**46**
	ILS/Spares/Govt. Supt.	77.3	72.1	56.7	51.5	51.5	51.5	51.5	51.5	51.5	0.0	**515**
S,R,C	**TOTAL**	171.1	204.8	277.9	349.6	365.0	363.4	363.6	364.8	353.0	98.5	**2,912**

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APPENDIX C. PROCUREMENT COST FORECAST AND ASSUMPTION DISTRIBUTIONS

Forecast: SLEP ONLY RDT&E TOTAL

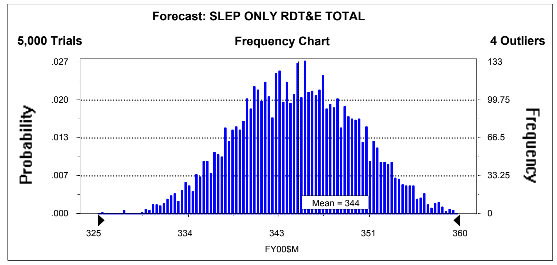
Crystal Ball Report
Simulation started on 10/1/01 at 15:09:41
Simulation stopped on 10/1/01 at 15:17:59

Summary:
Display Range is from 325 to 360 FY00$M
Entire Range is from 325 to 362 FY00$M
After 5,000 Trials, the Std. Error of the Mean is 0

Statistics:	Value
Trials	5000
Mean	344
Median	344
Mode	---
Standard Deviation	6
Variance	33
Skewness	0.02
Kurtosis	2.58
Coeff. of Variability	0.02
Range Minimum	325
Range Maximum	362
Range Width	36
Mean Std. Error	0.08

Percentiles:

Percentile	FY00$M
0%	325
10%	337
20%	339
30%	341
40%	343
50%	344
60%	346
70%	348
80%	349
90%	352
100%	362



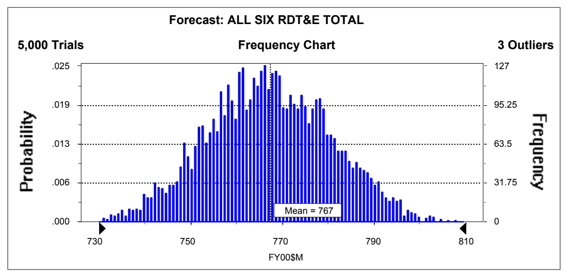
Forecast: ALL SIX RDT&E TOTAL

Summary:
Display Range is from 730 to 810 FY00$M
Entire Range is from 728 to 808 FY00$M
After 5,000 Trials, the Std. Error of the Mean is 0

Statistics:	Value
Trials	5000
Mean	767
Median	767
Mode	---
Standard Deviation	13
Variance	179
Skewness	0.01
Kurtosis	2.65
Coeff. of Variability	0.02
Range Minimum	728
Range Maximum	808
Range Width	80
Mean Std. Error	0.19

Percentiles:

Percentile	FY00$M
0%	728
10%	750
20%	756
30%	760
40%	764
50%	767
60%	770
70%	775
80%	779
90%	785
100%	808



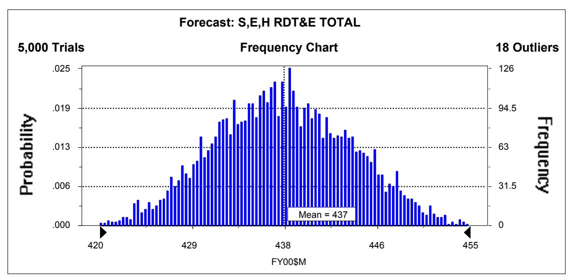
Forecast: S,E,H RDT&E TOTAL

Summary:
Display Range is from 420 to 455 FY00$M
Entire Range is from 417 to 458 FY00$M
After 5,000 Trials, the Std. Error of the Mean is 0

Statistics:	Value
Trials	5000
Mean	437
Median	437
Mode	---
Standard Deviation	6
Variance	42
Skewness	0.04
Kurtosis	2.67
Coeff. of Variability	0.01
Range Minimum	417
Range Maximum	458
Range Width	42
Mean Std. Error	0.09

Percentiles:

Percentile	FY00$M
0%	417
10%	429
20%	432
30%	434
40%	436
50%	437
60%	439
70%	441
80%	443
90%	446
100%	458



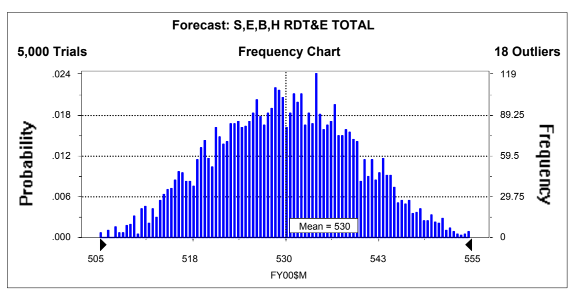
Forecast: S,E,B,H RDT&E TOTAL

Summary:
Display Range is from 505 to 555 FY00$M
Entire Range is from 502 to 559 FY00$M
After 5,000 Trials, the Std. Error of the Mean is 0

Statistics:	Value
Trials	5000
Mean	530
Median	530
Mode	---
Standard Deviation	10
Variance	91
Skewness	0.01
Kurtosis	2.58
Coeff. of Variability	0.02
Range Minimum	502
Range Maximum	559
Range Width	56
Mean Std. Error	0.13

Percentiles:

Percentile	FY00$M
0%	502
10%	517
20%	521
30%	525
40%	527
50%	530
60%	533
70%	535
80%	538
90%	543
100%	559



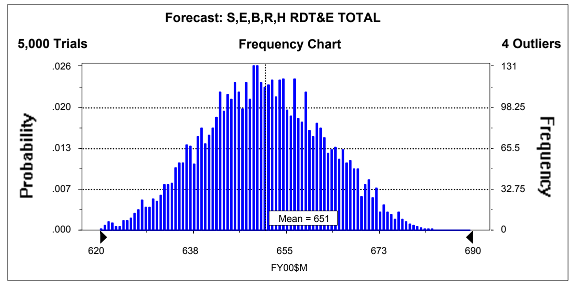
Forecast: S,E,B,R,H RDT&E TOTAL

Summary:
Display Range is from 620 to 690 FY00$M
Entire Range is from 618 to 683 FY00$M
After 5,000 Trials, the Std. Error of the Mean is 0

Statistics:	Value
Trials	5000
Mean	651
Median	651
Mode	---
Standard Deviation	11
Variance	128
Skewness	0.00
Kurtosis	2.58
Coeff. of Variability	0.02
Range Minimum	618
Range Maximum	683
Range Width	65
Mean Std. Error	0.16

Percentiles:

Percentile	FY00$M
0%	618
10%	636
20%	641
30%	645
40%	648
50%	651
60%	654
70%	657
80%	661
90%	666
100%	683



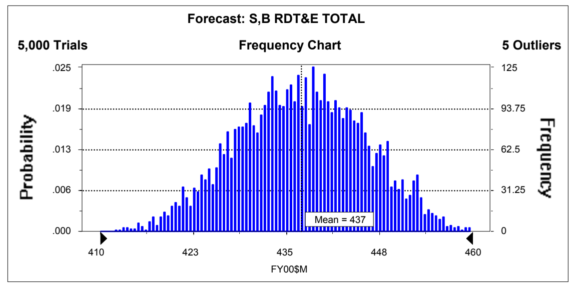
Forecast: S,B RDT&E TOTAL

Summary:
Display Range is from 410 to 460 FY00$M
Entire Range is from 412 to 462 FY00$M
After 5,000 Trials, the Std. Error of the Mean is 0

Statistics:	Value
Trials	5000
Mean	437
Median	437
Mode	---
Standard Deviation	9
Variance	74
Skewness	-0.03
Kurtosis	2.57
Coeff. of Variability	0.02
Range Minimum	412
Range Maximum	462
Range Width	50
Mean Std. Error	0.12

Percentiles:

Percentile	FY00$M
0%	412
10%	426
20%	429
30%	432
40%	435
50%	437
60%	439
70%	442
80%	445
90%	448
100%	462



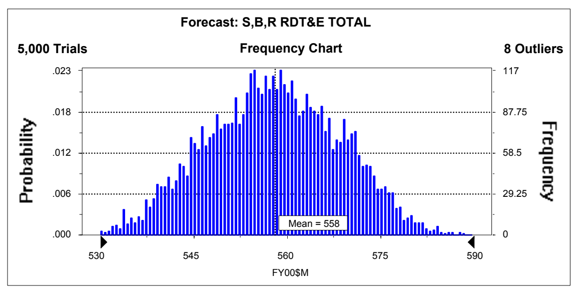
Forecast: S,B,R RDT&E TOTAL

Summary:
Display Range is from 530 to 590 FY00$M
Entire Range is from 527 to 592 FY00$M
After 5,000 Trials, the Std. Error of the Mean is 0

Statistics:	Value
Trials	5000
Mean	558
Median	558
Mode	---
Standard Deviation	11
Variance	112
Skewness	-0.03
Kurtosis	2.55
Coeff. of Variability	0.02
Range Minimum	527
Range Maximum	592
Range Width	64
Mean Std. Error	0.15

Percentiles:

Percentile	FY00$M
0%	527
10%	544
20%	548
30%	552
40%	555
50%	558
60%	561
70%	564
80%	567
90%	572
100%	592



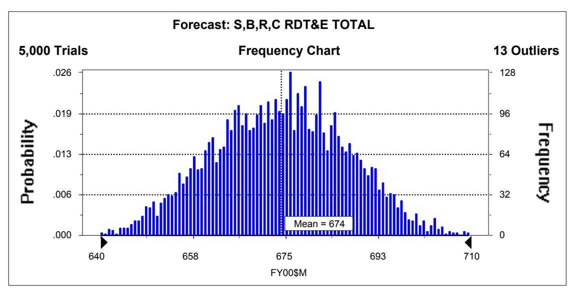
Forecast: S,B,R,C RDT&E TOTAL

Summary:
Display Range is from 640 to 710 FY00$M
Entire Range is from 637 to 713 FY00$M
After 5,000 Trials, the Std. Error of the Mean is 0

Statistics:	Value
Trials	5000
Mean	674
Median	674
Mode	---
Standard Deviation	13
Variance	160
Skewness	-0.02
Kurtosis	2.60
Coeff. of Variability	0.02
Range Minimum	637
Range Maximum	713
Range Width	76
Mean Std. Error	0.18

Percentiles:

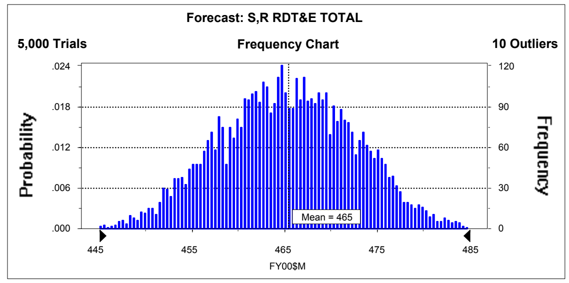
Percentile	FY00$M
0%	637
10%	657
20%	663
30%	667
40%	671
50%	674
60%	678
70%	681
80%	685
90%	691
100%	713



Forecast: S,R RDT&E TOTAL

Summary:
Display Range is from 445 to 485 FY00$M
Entire Range is from 444 to 489 FY00$M
After 5,000 Trials, the Std. Error of the Mean is 0

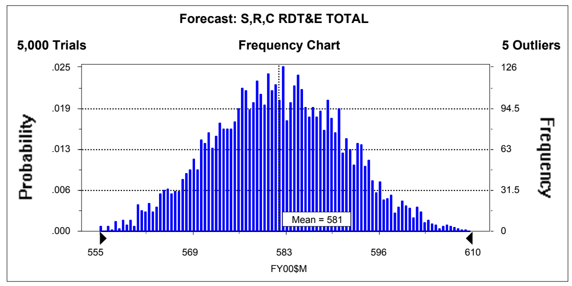
Statistics:	Value	Percentiles:	
Trials	5000		
Mean	465	Percentile	FY00$M
Median	465	0%	444
Mode	---	10%	456
Standard Deviation	7	20%	459
Variance	53	30%	461
Skewness	0.00	40%	463
Kurtosis	2.62	50%	465
Coeff. of Variability	0.02	60%	467
Range Minimum	444	70%	469
Range Maximum	489	80%	472
Range Width	45	90%	475
Mean Std. Error	0.10	100%	489



Forecast: S,R,C RDT&E TOTAL

Summary:
Display Range is from 555 to 610 FY00$M
Entire Range is from 551 to 610 FY00$M
After 5,000 Trials, the Std. Error of the Mean is 0

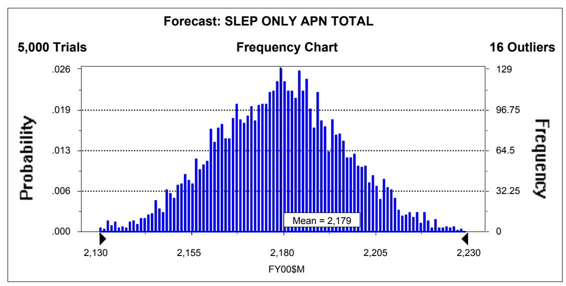
Statistics:	Value	Percentiles:	
Trials	5000		
Mean	581	Percentile	FY00$M
Median	581	0%	551
Mode	---	10%	569
Standard Deviation	10	20%	573
Variance	92	30%	576
Skewness	0.00	40%	579
Kurtosis	2.68	50%	581
Coeff. of Variability	0.02	60%	584
Range Minimum	551	70%	587
Range Maximum	610	80%	590
Range Width	59	90%	594
Mean Std. Error	0.14	100%	610



Forecast: SLEP ONLY APN TOTAL

Summary:
Display Range is from 2,130 to 2,230 FY00$M
Entire Range is from 2,123 to 2,238 FY00$M
After 5,000 Trials, the Std. Error of the Mean is 0

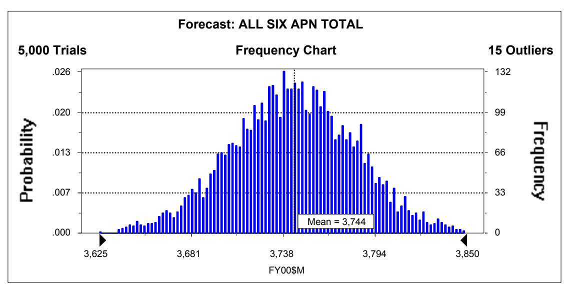
Statistics:	Value	Percentiles:	
Trials	5000		
Mean	2,179	Percentile	FY00$M
Median	2,179	0%	2,123
Mode	---	10%	2,156
Standard Deviation	18	20%	2,164
Variance	307	30%	2,170
Skewness	-0.03	40%	2,175
Kurtosis	2.86	50%	2,179
Coeff. of Variability	0.01	60%	2,184
Range Minimum	2,123	70%	2,188
Range Maximum	2,238	80%	2,194
Range Width	115	90%	2,202
Mean Std. Error	0.25	100%	2,238



Forecast: ALL SIX APN TOTAL

Summary:
Display Range is from 3,625 to 3,850 FY00$M
Entire Range is from 3,607 to 3,871 FY00$M
After 5,000 Trials, the Std. Error of the Mean is 1

Statistics:	Value	Percentiles:	
Trials	5000		
Mean	3,744	Percentile	FY00$M
Median	3,744	0%	3,607
Mode	---	10%	3,695
Standard Deviation	38	20%	3,712
Variance	1,460	30%	3,724
Skewness	-0.03	40%	3,734
Kurtosis	2.93	50%	3,744
Coeff. of Variability	0.01	60%	3,754
Range Minimum	3,607	70%	3,764
Range Maximum	3,871	80%	3,777
Range Width	264	90%	3,792
Mean Std. Error	0.54	100%	3,871



Forecast: S,E,H APN TOTAL

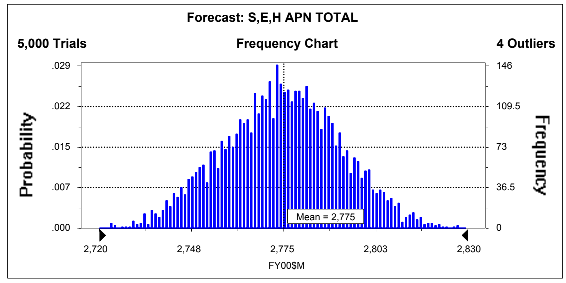
Summary:

Display Range is from 2,720 to 2,830 FY00$M
Entire Range is from 2,710 to 2,833 FY00$M
After 5,000 Trials, the Std. Error of the Mean is 0

Statistics:	Value
Trials	5000
Mean	2,775
Median	2,775
Mode	---
Standard Deviation	18
Variance	311
Skewness	-0.04
Kurtosis	2.83
Coeff. of Variability	0.01
Range Minimum	2,710
Range Maximum	2,833
Range Width	124
Mean Std. Error	0.25

Percentiles:

Percentile	FY00$M
0%	2,710
10%	2,751
20%	2,760
30%	2,766
40%	2,771
50%	2,775
60%	2,780
70%	2,784
80%	2,790
90%	2,798
100%	2,833



Forecast: S,E,B,H APN TOTAL

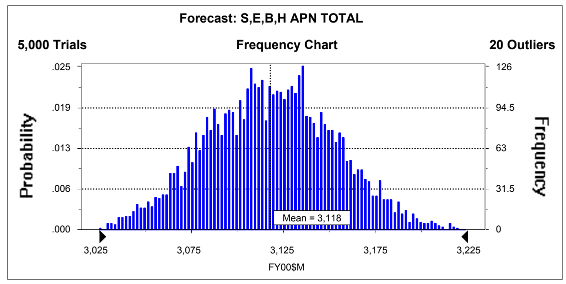
Summary:

Display Range is from 3,025 to 3,225 FY00$M
Entire Range is from 3,009 to 3,220 FY00$M
After 5,000 Trials, the Std. Error of the Mean is 0

Statistics:	Value
Trials	5000
Mean	3,118
Median	3,118
Mode	---
Standard Deviation	35
Variance	1,233
Skewness	-0.03
Kurtosis	2.75
Coeff. of Variability	0.01
Range Minimum	3,009
Range Maximum	3,220
Range Width	210
Mean Std. Error	0.50

Percentiles:

Percentile	FY00$M
0%	3,009
10%	3,073
20%	3,087
30%	3,099
40%	3,109
50%	3,118
60%	3,128
70%	3,137
80%	3,148
90%	3,163
100%	3,220



Forecast: S,E,B,R,H APN TOTAL

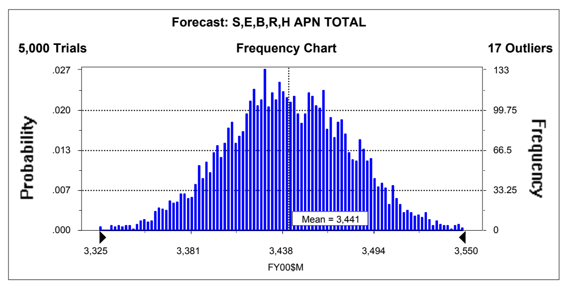
Summary:

Display Range is from 3,325 to 3,550 FY00$M
Entire Range is from 3,318 to 3,565 FY00$M
After 5,000 Trials, the Std. Error of the Mean is 1

Statistics:	Value
Trials	5000
Mean	3,441
Median	3,440
Mode	---
Standard Deviation	38
Variance	1,481
Skewness	0.04
Kurtosis	2.86
Coeff. of Variability	0.01
Range Minimum	3,318
Range Maximum	3,565
Range Width	247
Mean Std. Error	0.54

Percentiles:

Percentile	FY00$M
0%	3,318
10%	3,392
20%	3,408
30%	3,420
40%	3,431
50%	3,440
60%	3,452
70%	3,462
80%	3,474
90%	3,491
100%	3,565



Forecast: S,B APN TOTAL

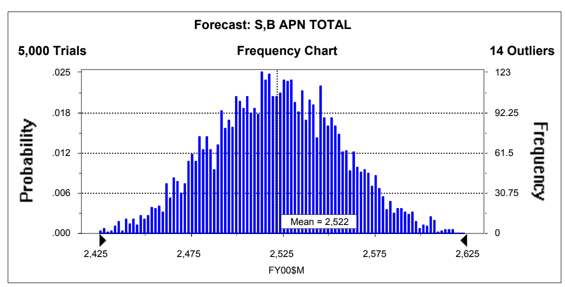
Summary:

Display Range is from 2,425 to 2,625 FY00$M
Entire Range is from 2,400 to 2,649 FY00$M
After 5,000 Trials, the Std. Error of the Mean is 0

Statistics:	Value
Trials	5000
Mean	2,522
Median	2,522
Mode	---
Standard Deviation	35
Variance	1,215
Skewness	0.01
Kurtosis	2.78
Coeff. of Variability	0.01
Range Minimum	2,400
Range Maximum	2,649
Range Width	249
Mean Std. Error	0.49

Percentiles:

Percentile	FY00$M
0%	2,400
10%	2,476
20%	2,492
30%	2,503
40%	2,513
50%	2,522
60%	2,530
70%	2,541
80%	2,552
90%	2,567
100%	2,649

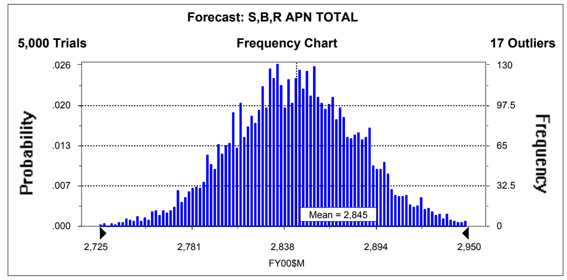


Forecast: S,B,R APN TOTAL

Summary:

Display Range is from 2,725 to 2,950 FY00$M
Entire Range is from 2,710 to 2,982 FY00$M
After 5,000 Trials, the Std. Error of the Mean is 1

Statistics:	Value	Percentiles:	
Trials	5000		
Mean	2,845	Percentile	FY00$M
Median	2,845	0%	2,710
Mode	---	10%	2,796
Standard Deviation	38	20%	2,812
Variance	1,472	30%	2,825
Skewness	0.00	40%	2,835
Kurtosis	2.93	50%	2,845
Coeff. of Variability	0.01	60%	2,855
Range Minimum	2,710	70%	2,865
Range Maximum	2,982	80%	2,878
Range Width	273	90%	2,894
Mean Std. Error	0.54	100%	2,982

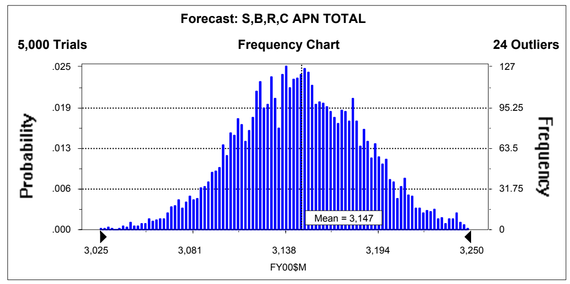


Forecast: S,B,R,C APN TOTAL

Summary:

Display Range is from 3,025 to 3,250 FY00$M
Entire Range is from 3,020 to 3,269 FY00$M
After 5,000 Trials, the Std. Error of the Mean is 1

Statistics:	Value	Percentiles:	
Trials	5000		
Mean	3,147	Percentile	FY00$M
Median	3,147	0%	3,020
Mode	---	10%	3,099
Standard Deviation	39	20%	3,114
Variance	1,485	30%	3,126
Skewness	0.05	40%	3,137
Kurtosis	2.91	50%	3,147
Coeff. of Variability	0.01	60%	3,156
Range Minimum	3,020	70%	3,168
Range Maximum	3,269	80%	3,180
Range Width	248	90%	3,197
Mean Std. Error	0.54	100%	3,269

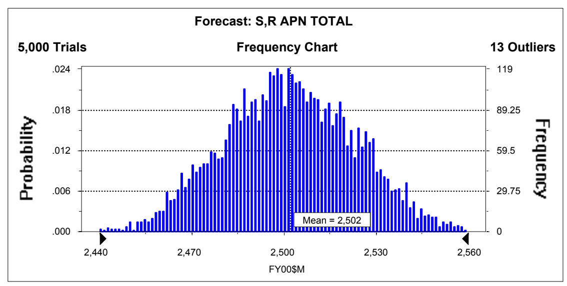


Forecast: S,R APN TOTAL

Summary:

Display Range is from 2,440 to 2,560 FY00$M
Entire Range is from 2,432 to 2,576 FY00$M
After 5,000 Trials, the Std. Error of the Mean is 0

Statistics:	Value	Percentiles:	
Trials	5000		
Mean	2,502	Percentile	FY00$M
Median	2,502	0%	2,432
Mode	---	10%	2,474
Standard Deviation	21	20%	2,484
Variance	451	30%	2,491
Skewness	0.03	40%	2,497
Kurtosis	2.71	50%	2,502
Coeff. of Variability	0.01	60%	2,507
Range Minimum	2,432	70%	2,514
Range Maximum	2,576	80%	2,521
Range Width	144	90%	2,530
Mean Std. Error	0.30	100%	2,576

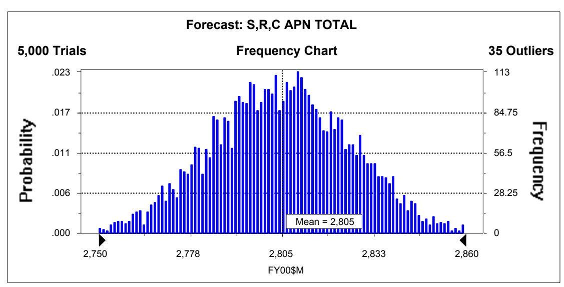


Forecast: S,R,C APN TOTAL

Summary:

Display Range is from 2,750 to 2,860 FY00$M
Entire Range is from 2,728 to 2,878 FY00$M
After 5,000 Trials, the Std. Error of the Mean is 0

Statistics:	Value	Percentiles:	
Trials	5000		
Mean	2,805	Percentile	FY00$M
Median	2,805	0%	2,728
Mode	---	10%	2,778
Standard Deviation	21	20%	2,787
Variance	443	30%	2,793
Skewness	0.01	40%	2,799
Kurtosis	2.88	50%	2,805
Coeff. of Variability	0.01	60%	2,810
Range Minimum	2,728	70%	2,816
Range Maximum	2,878	80%	2,823
Range Width	149	90%	2,832
Mean Std. Error	0.30	100%	2,878



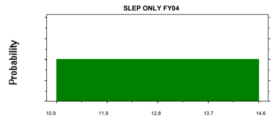
Crystal Ball Report
Simulation started on 10/1/01 at 15:09:41
Simulation stopped on 10/1/01 at 15:17:59

Assumptions

Assumption: SLEP ONLY FY04

Uniform distribution with parameters:
Minimum 10.9 (=C25)
Maximum 14.6 (=O25)
Mean value in simulation was 12.8

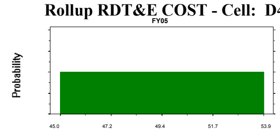
Rollup RDT&E COST - Cell: C4



Assumption: FY05

Uniform distribution with parameters:
Minimum 45.0 (=D25)
Maximum 53.9 (=P25)
Mean value in simulation was 49.5

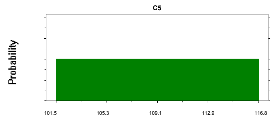
Rollup RDT&E COST - Cell: D4



Assumption: C5

Uniform distribution with parameters:
Minimum 101.5 (=C40)
Maximum 116.8 (=O40)
Mean value in simulation was 109.0

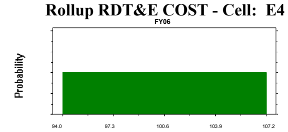
Rollup RDT&E COST - Cell: C5



Assumption: FY06

Uniform distribution with parameters:
Minimum 94.0 (=E25)
Maximum 107.2 (=Q25)
Mean value in simulation was 100.7

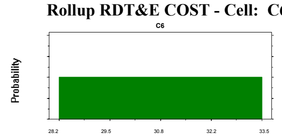
Rollup RDT&E COST - Cell: E4



Assumption: C6

Uniform distribution with parameters:
Minimum 28.2 (=C51)
Maximum 33.5 (=O51)
Mean value in simulation was 30.9

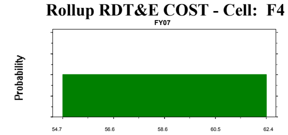
Rollup RDT&E COST - Cell: C6



Assumption: FY07

Uniform distribution with parameters:
Minimum 54.7 (=F25)
Maximum 62.4 (=R25)
Mean value in simulation was 58.5

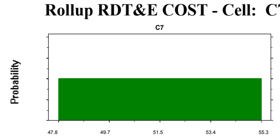
Rollup RDT&E COST - Cell: F4



Assumption: C7

Uniform distribution with parameters:
Minimum 47.8 (=C63)
Maximum 55.3 (=O63)
Mean value in simulation was 51.6

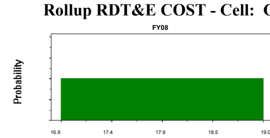
Rollup RDT&E COST - Cell: C7



Assumption: FY08

Uniform distribution with parameters:
Minimum 16.9 (=G25)
Maximum 19.0 (=S25)
Mean value in simulation was 17.9

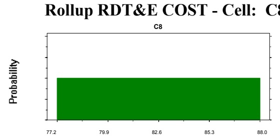
Rollup RDT&E COST - Cell: G4



Assumption: C8

Uniform distribution with parameters:
Minimum 77.2 (=C76)
Maximum 88.0 (=O76)
Mean value in simulation was 82.5

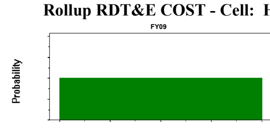
Rollup RDT&E COST - Cell: C8



Assumption: FY09

Uniform distribution with parameters:
Minimum 40.7 (=H25)
Maximum 45.7 (=T25)
Mean value in simulation was 43.2

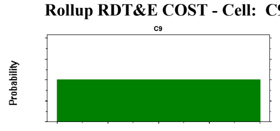
Rollup RDT&E COST - Cell: H4



Assumption: C9

Uniform distribution with parameters:
Minimum 30.5 (=C86)
Maximum 36.4 (=O86)
Mean value in simulation was 33.5

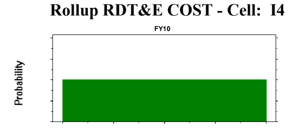
Rollup RDT&E COST - Cell: C9



Assumption: FY10

Uniform distribution with parameters:
Minimum 29.0 (=I25)
Maximum 32.7 (=U25)
Mean value in simulation was 30.9

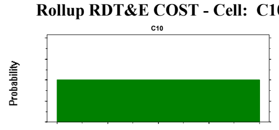
Rollup RDT&E COST - Cell: I4



Assumption: C10

Uniform distribution with parameters:
Minimum 59.9 (=C97)
Maximum 69.1 (=O97)
Mean value in simulation was 64.5

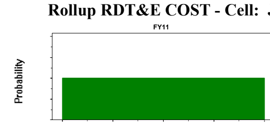
Rollup RDT&E COST - Cell: C10



Assumption: FY11

Uniform distribution with parameters:
Minimum 29.0 (=J25)
Maximum 32.7 (=V25)
Mean value in simulation was 30.9

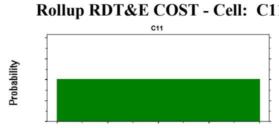
Rollup RDT&E COST - Cell: J4



Assumption: C11

Uniform distribution with parameters:
Minimum 84.3 (=C110)
Maximum 97.9 (=O110)
Mean value in simulation was 91.1

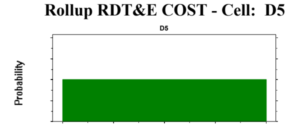
Rollup RDT&E COST - Cell: C11



Assumption: D5

Uniform distribution with parameters:
Minimum 190.8 (=D40)
Maximum 219.3 (=P40)
Mean value in simulation was 205.1

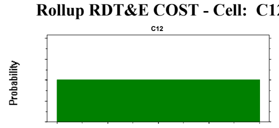
Rollup RDT&E COST - Cell: D5



Assumption: C12

Uniform distribution with parameters:
Minimum 40.3 (=C120)
Maximum 47.3 (=O120)
Mean value in simulation was 43.8

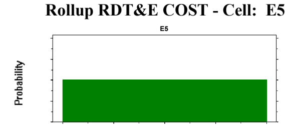
Rollup RDT&E COST - Cell: C12



Assumption: E5

Uniform distribution with parameters:
Minimum 204.5 (=E40)
Maximum 235.0 (=Q40)
Mean value in simulation was 219.7

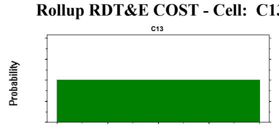
Rollup RDT&E COST - Cell: E5



Assumption: C13

Uniform distribution with parameters:
Minimum 64.7 (=C132)
Maximum 76.1 (=O132)
Mean value in simulation was 70.4

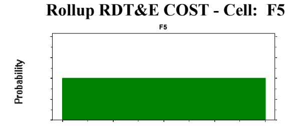
Rollup RDT&E COST - Cell: C13



Assumption: F5

Uniform distribution with parameters:
Minimum 90.2 (=F40)
Maximum 102.9 (=R40)
Mean value in simulation was 96.6

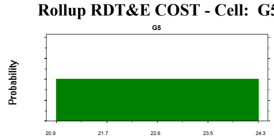
Rollup RDT&E COST - Cell: F5



Assumption: G5
Uniform distribution with parameters:
Minimum 20.9 (=G40)
Maximum 24.3 (=S40)

Mean value in simulation was 22.6

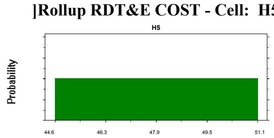
Rollup RDT&E COST - Cell: G5



Assumption: H5
Uniform distribution with parameters:
Minimum 44.6 (=H40)
Maximum 51.1 (=T40)

Mean value in simulation was 47.8

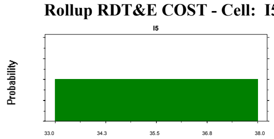
]Rollup RDT&E COST - Cell: H5



Assumption: I5
Uniform distribution with parameters:
Minimum 33.0 (=I40)
Maximum 38.0 (=U40)

Mean value in simulation was 35.5

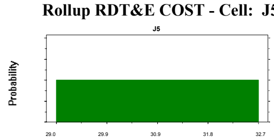
Rollup RDT&E COST - Cell: I5



Assumption: J5
Uniform distribution with parameters:
Minimum 29.0 (=J40)
Maximum 32.7 (=V40)

Mean value in simulation was 30.9

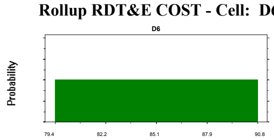
Rollup RDT&E COST - Cell: J5



Assumption: D6
Uniform distribution with parameters:
Minimum 79.4 (=D51)
Maximum 90.8 (=P51)

Mean value in simulation was 85.1

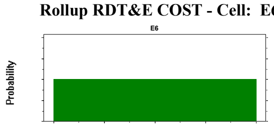
Rollup RDT&E COST - Cell: D6



Assumption: E6
Uniform distribution with parameters:
Minimum 125.0 (=E51)
Maximum 139.8 (=Q51)

Mean value in simulation was 132.4

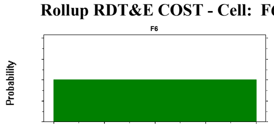
Rollup RDT&E COST - Cell: E6



Assumption: F6
Uniform distribution with parameters:
Minimum 62.1 (=F51)
Maximum 70.4 (=R51)

Mean value in simulation was 66.2

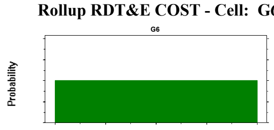
Rollup RDT&E COST - Cell: F6



Assumption: G6
Uniform distribution with parameters:
Minimum 16.9 (=G51)
Maximum 19.0 (=S51)

Mean value in simulation was 17.9

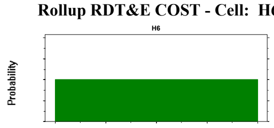
Rollup RDT&E COST - Cell: G6



Assumption: H6
Uniform distribution with parameters:
Minimum 40.7 (=H51)
Maximum 45.7 (=T51)

Mean value in simulation was 43.2

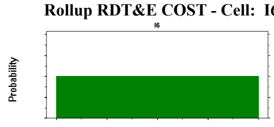
Rollup RDT&E COST - Cell: H6



Assumption: I6
Uniform distribution with parameters:
Minimum 29.0 (=I51)
Maximum 32.7 (=U51)

Mean value in simulation was 30.8

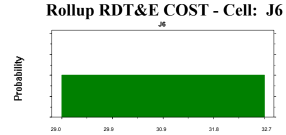
Rollup RDT&E COST - Cell: I6



Assumption: J6
Uniform distribution with parameters:
Minimum 29.0 (=J51)
Maximum 32.7 (=V51)

Mean value in simulation was 30.8

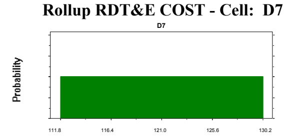
Rollup RDT&E COST - Cell: J6



Assumption: D7
Uniform distribution with parameters:
Minimum 111.8 (=D63)
Maximum 130.2 (=P63)

Mean value in simulation was 120.9

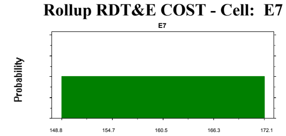
Rollup RDT&E COST - Cell: D7



Assumption: E7
Uniform distribution with parameters:
Minimum 148.8 (=E63)
Maximum 172.1 (=Q63)

Mean value in simulation was 160.4

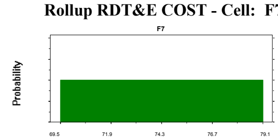
Rollup RDT&E COST - Cell: E7



Assumption: F7
Uniform distribution with parameters:
Minimum 69.5 (=F63)
Maximum 79.1 (=R63)

Mean value in simulation was 74.3

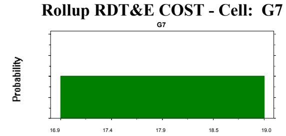
Rollup RDT&E COST - Cell: F7



Assumption: G7
Uniform distribution with parameters:
Minimum 16.9 (=G63)
Maximum 19.0 (=S63)

Mean value in simulation was 17.9

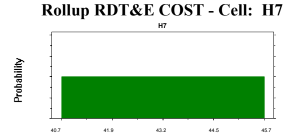
Rollup RDT&E COST - Cell: G7



Assumption: H7
Uniform distribution with parameters:
Minimum 40.7 (=H63)
Maximum 45.7 (=T63)

Mean value in simulation was 43.2

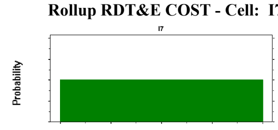
Rollup RDT&E COST - Cell: H7



Assumption: I7
Uniform distribution with parameters:
Minimum 29.0 (=I63)
Maximum 32.7 (=U63)

Mean value in simulation was 30.9

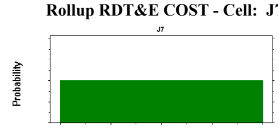
Rollup RDT&E COST - Cell: I7



Assumption: J7
Uniform distribution with parameters:
Minimum 29.0 (=J63)
Maximum 32.7 (=V63)

Mean value in simulation was 30.9

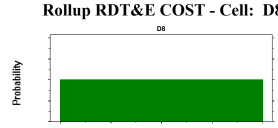
Rollup RDT&E COST - Cell: J7



Assumption: D8
Uniform distribution with parameters:
Minimum 156.8 (=D76)
Maximum 180.2 (=P76)

Mean value in simulation was 168.4

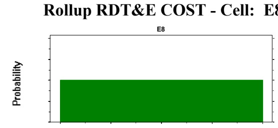
Rollup RDT&E COST - Cell: D8



Assumption: E8
Uniform distribution with parameters:
Minimum 178.4 (=E76)
Maximum 204.9 (=Q76)

Mean value in simulation was 191.7

Rollup RDT&E COST - Cell: E8

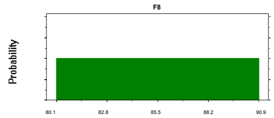


Assumption: F8

Uniform distribution with parameters:
Minimum 80.1 (=F76)
Maximum 90.9 (=R76)

Mean value in simulation was 85.5

Rollup RDT&E COST - Cell: F8

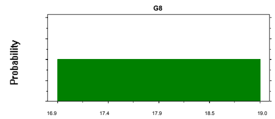


Assumption: G8

Uniform distribution with parameters:
Minimum 16.9 (=G76)
Maximum 19.0 (=S76)

Mean value in simulation was 17.9

Rollup RDT&E COST - Cell: G8

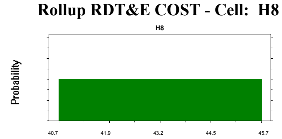


Assumption: H8

Uniform distribution with parameters:
Minimum 40.7 (=H76)
Maximum 45.7 (=T76)

Mean value in simulation was 43.2

Rollup RDT&E COST - Cell: H8

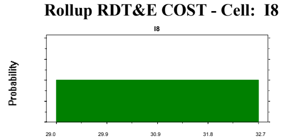


Assumption: I8

Uniform distribution with parameters:
Minimum 29.0 (=I76)
Maximum 32.7 (=U76)

Mean value in simulation was 30.8

Rollup RDT&E COST - Cell: I8

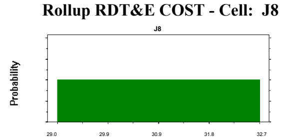


Assumption: J8

Uniform distribution with parameters:
Minimum 29.0 (=J76)
Maximum 32.7 (=V76)

Mean value in simulation was 30.9

Rollup RDT&E COST - Cell: J8

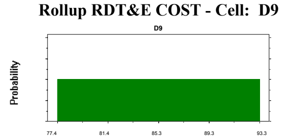


Assumption: D9

Uniform distribution with parameters:
Minimum 77.4 (=D86)
Maximum 93.3 (=P86)

Mean value in simulation was 85.4

Rollup RDT&E COST - Cell: D9

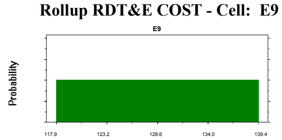


Assumption: E9

Uniform distribution with parameters:
Minimum 117.9 (=E86)
Maximum 139.4 (=Q86)

Mean value in simulation was 128.8

Rollup RDT&E COST - Cell: E9

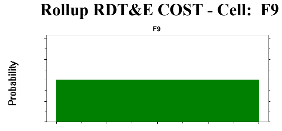


Assumption: F9

Uniform distribution with parameters:
Minimum 62.2 (=F86)
Maximum 71.1 (=R86)

Mean value in simulation was 66.6

Rollup RDT&E COST - Cell: F9

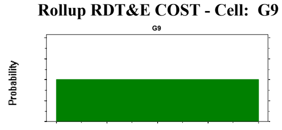


Assumption: G9

Uniform distribution with parameters:
Minimum 16.9 (=G86)
Maximum 19.0 (=S86)

Mean value in simulation was 17.9

Rollup RDT&E COST - Cell: G9

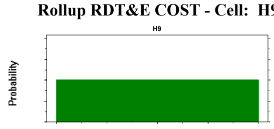


Assumption: H9

Uniform distribution with parameters:
Minimum 40.7 (=H86)
Maximum 45.7 (=T86)

Mean value in simulation was 43.2

Rollup RDT&E COST - Cell: H9

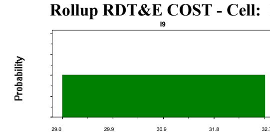


Assumption: I9

Uniform distribution with parameters:
Minimum 29.0 (=I86)
Maximum 32.7 (=U86)

Mean value in simulation was 30.9

Rollup RDT&E COST - Cell: I9

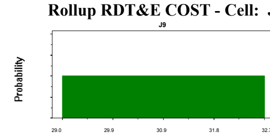


Assumption: J9

Uniform distribution with parameters:
Minimum 29.0 (=J86)
Maximum 32.7 (=V86)

Mean value in simulation was 30.9

Rollup RDT&E COST - Cell: J9

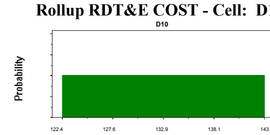


Assumption: D10

Uniform distribution with parameters:
Minimum 122.4 (=D97)
Maximum 143.3 (=P97)

Mean value in simulation was 132.8

Rollup RDT&E COST - Cell: D10

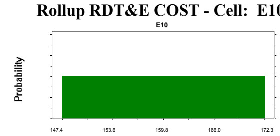


Assumption: E10

Uniform distribution with parameters:
Minimum 147.4 (=E97)
Maximum 172.3 (=Q97)

Mean value in simulation was 159.9

Rollup RDT&E COST - Cell: E10

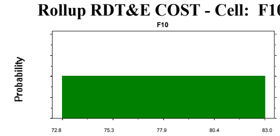


Assumption: F10

Uniform distribution with parameters:
Minimum 72.8 (=F97)
Maximum 83.0 (=R97)

Mean value in simulation was 77.8

Rollup RDT&E COST - Cell: F10

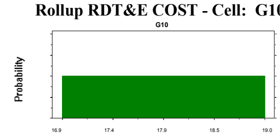


Assumption: G10

Uniform distribution with parameters:
Minimum 16.9 (=G97)
Maximum 19.0 (=S97)

Mean value in simulation was 17.9

Rollup RDT&E COST - Cell: G10

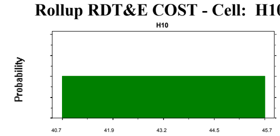


Assumption: H10

Uniform distribution with parameters:
Minimum 40.7 (=H97)
Maximum 45.7 (=T97)

Mean value in simulation was 43.2

Rollup RDT&E COST - Cell: H10

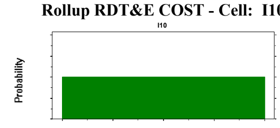


Assumption: I10

Uniform distribution with parameters:
Minimum 29.0 (=I97)
Maximum 32.7 (=U97)

Mean value in simulation was 30.9

Rollup RDT&E COST - Cell: I10

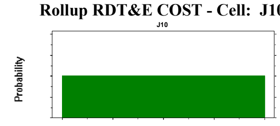


Assumption: J10

Uniform distribution with parameters:
Minimum 29.0 (=J97)
Maximum 32.7 (=V97)

Mean value in simulation was 30.9

Rollup RDT&E COST - Cell: J10

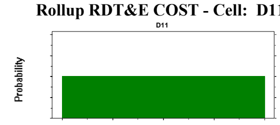


Assumption: D11

Uniform distribution with parameters:
Minimum 156.4 (=D110)
Maximum 182.4 (=P110)

Mean value in simulation was 169.2

Rollup RDT&E COST - Cell: D11



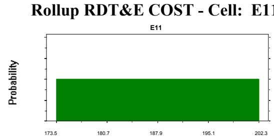
Assumption: E11

Uniform distribution with parameters:

Minimum	173.5	(=E110)
Maximum	202.3	(=Q110)

Mean value in simulation was 188.0

Rollup RDT&E COST - Cell: E11



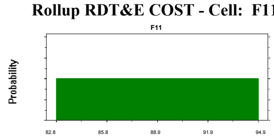
Assumption: F11

Uniform distribution with parameters:

Minimum	82.8	(=F110)
Maximum	94.9	(=R110)

Mean value in simulation was 88.9

Rollup RDT&E COST - Cell: F11



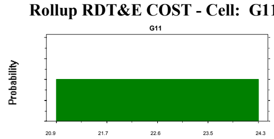
Assumption: G11

Uniform distribution with parameters:

Minimum	20.9	(=G110)
Maximum	24.3	(=S110)

Mean value in simulation was 22.6

Rollup RDT&E COST - Cell: G11



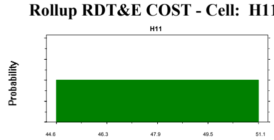
Assumption: H11

Uniform distribution with parameters:

Minimum	44.6	(=H110)
Maximum	51.1	(=T110)

Mean value in simulation was 47.8

Rollup RDT&E COST - Cell: H11



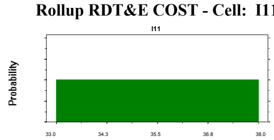
Assumption: I11

Uniform distribution with parameters:

Minimum	33.0	(=I110)
Maximum	38.0	(=U110)

Mean value in simulation was 35.5

Rollup RDT&E COST - Cell: I11



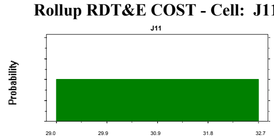
Assumption: J11

Uniform distribution with parameters:

Minimum	29.0	(=J110)
Maximum	32.7	(=V110)

Mean value in simulation was 30.9

Rollup RDT&E COST - Cell: J11



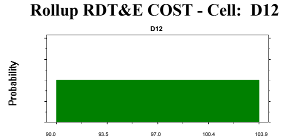
Assumption: D12

Uniform distribution with parameters:

Minimum	90.0	(=D120)
Maximum	103.9	(=P120)

Mean value in simulation was 97.0

Rollup RDT&E COST - Cell: D12



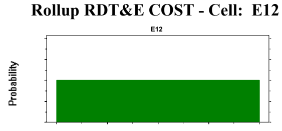
Assumption: E12

Uniform distribution with parameters:

Minimum	123.5	(=E120)
Maximum	140.0	(=Q120)

Mean value in simulation was 131.8

Rollup RDT&E COST - Cell: E12



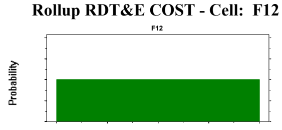
Assumption: F12

Uniform distribution with parameters:

Minimum	65.3	(=F120)
Maximum	74.2	(=R120)

Mean value in simulation was 69.8

Rollup RDT&E COST - Cell: F12



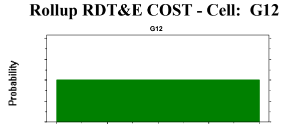
Assumption: G12

Uniform distribution with parameters:

Minimum	16.9	(=G120)
Maximum	19.0	(=S120)

Mean value in simulation was 17.9

Rollup RDT&E COST - Cell: G12



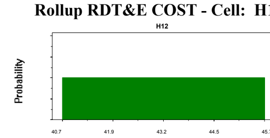
Assumption: H12

Uniform distribution with parameters:

Minimum	40.7	(=H120)
Maximum	45.7	(=T120)

Mean value in simulation was 43.2

Rollup RDT&E COST - Cell: H12



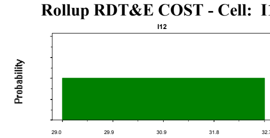
Assumption: I12

Uniform distribution with parameters:

Minimum	29.0	(=I120)
Maximum	32.7	(=U120)

Mean value in simulation was 30.9

Rollup RDT&E COST - Cell: I12



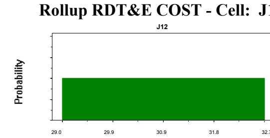
Assumption: J12

Uniform distribution with parameters:

Minimum	29.0	(=J120)
Maximum	32.7	(=V120)

Mean value in simulation was 30.9

Rollup RDT&E COST - Cell: J12



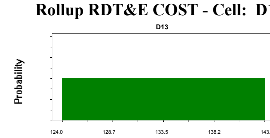
Assumption: D13

Uniform distribution with parameters:

Minimum	124.0	(=D132)
Maximum	143.0	(=P132)

Mean value in simulation was 133.5

Rollup RDT&E COST - Cell: D13



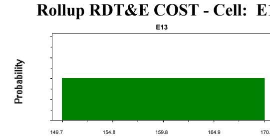
Assumption: E13

Uniform distribution with parameters:

Minimum	149.7	(=E132)
Maximum	170.0	(=Q132)

Mean value in simulation was 159.9

Rollup RDT&E COST - Cell: E13



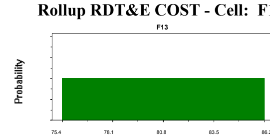
Assumption: F13

Uniform distribution with parameters:

Minimum	75.4	(=F132)
Maximum	86.2	(=R132)

Mean value in simulation was 80.7

Rollup RDT&E COST - Cell: F13



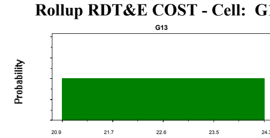
Assumption: G13

Uniform distribution with parameters:

Minimum	20.9	(=G132)
Maximum	24.3	(=S132)

Mean value in simulation was 22.6

Rollup RDT&E COST - Cell: G13



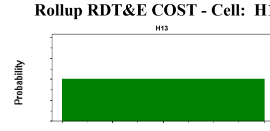
Assumption: H13

Uniform distribution with parameters:

Minimum	44.6	(=H132)
Maximum	51.1	(=T132)

Mean value in simulation was 47.9

Rollup RDT&E COST - Cell: H13



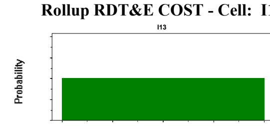
Assumption: I13

Uniform distribution with parameters:

Minimum	33.0	(=I132)
Maximum	38.0	(=U132)

Mean value in simulation was 35.5

Rollup RDT&E COST - Cell: I13



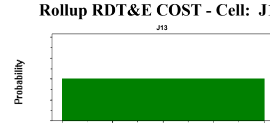
Assumption: J13

Uniform distribution with parameters:

Minimum	29.0	(=J132)
Maximum	32.7	(=V132)

Mean value in simulation was 30.9

Rollup RDT&E COST - Cell: J13

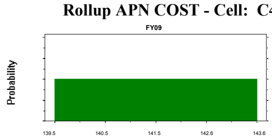


Assumption: FY09

Uniform distribution with parameters:
Minimum 139.5 (=C24)
Maximum 143.6 (=Q24)

Mean value in simulation was 141.5

Rollup APN COST - Cell: C4

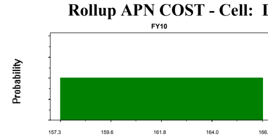


Assumption: FY10

Uniform distribution with parameters:
Minimum 157.3 (=D24)
Maximum 166.2 (=R24)

Mean value in simulation was 161.8

Rollup APN COST - Cell: D4

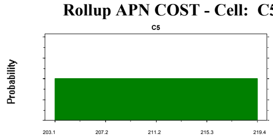


Assumption: C5

Uniform distribution with parameters:
Minimum 203.1 (=C36)
Maximum 219.4 (=Q36)

Mean value in simulation was 211.2

Rollup APN COST - Cell: C5

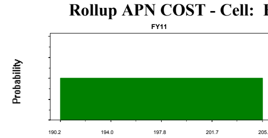


Assumption: FY11

Uniform distribution with parameters:
Minimum 190.2 (=E24)
Maximum 205.5 (=S24)

Mean value in simulation was 197.8

Rollup APN COST - Cell: E4

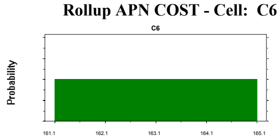


Assumption: C6

Uniform distribution with parameters:
Minimum 161.1 (=C45)
Maximum 165.1 (=Q45)

Mean value in simulation was 163.1

Rollup APN COST - Cell: C6

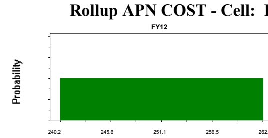


Assumption: FY12

Uniform distribution with parameters:
Minimum 240.2 (=F24)
Maximum 262.0 (=T24)

Mean value in simulation was 251.3

Rollup APN COST - Cell: F4

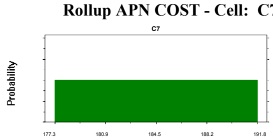


Assumption: C7

Uniform distribution with parameters:
Minimum 177.3 (=C55)
Maximum 191.8 (=Q55)

Mean value in simulation was 184.5

Rollup APN COST - Cell: C7

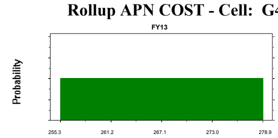


Assumption: FY13

Uniform distribution with parameters:
Minimum 255.3 (=G24)
Maximum 278.9 (=U24)

Mean value in simulation was 267.2

Rollup APN COST - Cell: G4

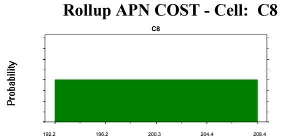


Assumption: C8

Uniform distribution with parameters:
Minimum 192.2 (=C66)
Maximum 208.4 (=Q66)

Mean value in simulation was 200.3

Rollup APN COST - Cell: C8

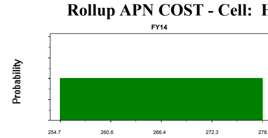


Assumption: FY14

Uniform distribution with parameters:
Minimum 254.7 (=H24)
Maximum 278.2 (=V24)

Mean value in simulation was 266.5

Rollup APN COST - Cell: H4

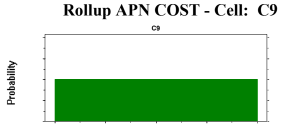


Assumption: C9

Uniform distribution with parameters:
Minimum 155.7 (=C75)
Maximum 170.2 (=Q75)

Mean value in simulation was 162.9

Rollup APN COST - Cell: C9

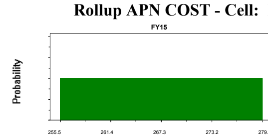


Assumption: FY15

Uniform distribution with parameters:
Minimum 255.5 (=I24)
Maximum 279.1 (=W24)

Mean value in simulation was 267.3

Rollup APN COST - Cell: I4

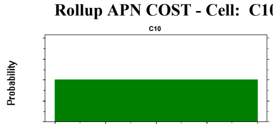


Assumption: C10

Uniform distribution with parameters:
Minimum 170.6 (=C85)
Maximum 186.9 (=Q85)

Mean value in simulation was 178.8

Rollup APN COST - Cell: C10

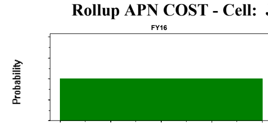


Assumption: FY16

Uniform distribution with parameters:
Minimum 257.1 (=J24)
Maximum 280.9 (=X24)

Mean value in simulation was 269.0

Rollup APN COST - Cell: J4

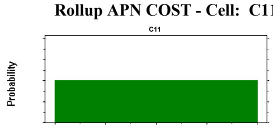


Assumption: C11

Uniform distribution with parameters:
Minimum 181.5 (=C96)
Maximum 197.8 (=Q96)

Mean value in simulation was 189.8

Rollup APN COST - Cell: C11

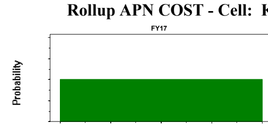


Assumption: FY17

Uniform distribution with parameters:
Minimum 251.8 (=K24)
Maximum 274.9 (=Y24)

Mean value in simulation was 263.2

Rollup APN COST - Cell: K4

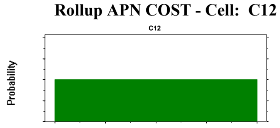


Assumption: C12

Uniform distribution with parameters:
Minimum 154.4 (=C105)
Maximum 160.2 (=Q105)

Mean value in simulation was 157.3

Rollup APN COST - Cell: C12

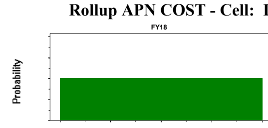


Assumption: FY18

Uniform distribution with parameters:
Minimum 88.5 (=L24)
Maximum 98.5 (=Z24)

Mean value in simulation was 93.5

Rollup APN COST - Cell: L4

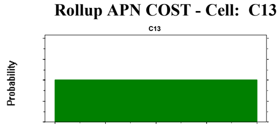


Assumption: C13

Uniform distribution with parameters:
Minimum 165.3 (=C115)
Maximum 171.1 (=Q115)

Mean value in simulation was 168.3

Rollup APN COST - Cell: C13

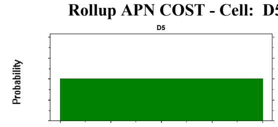


Assumption: D5

Uniform distribution with parameters:
Minimum 244.6 (=D36)
Maximum 269.1 (=R36)

Mean value in simulation was 256.9

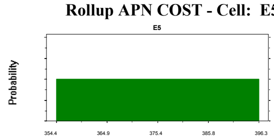
Rollup APN COST - Cell: D5



Assumption: E5

Uniform distribution with parameters:
Minimum 354.4 (=E36)
Maximum 396.3 (=S36)

Rollup APN COST - Cell: E5

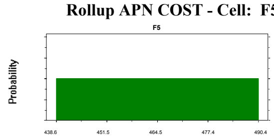


Mean value in simulation was 375.3

Assumption: F5

Uniform distribution with parameters:
Minimum 438.6 (=F36)
Maximum 490.4 (=T36)

Rollup APN COST - Cell: F5

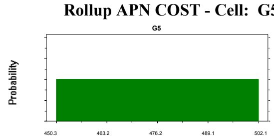


Mean value in simulation was 464.7

Assumption: G5

Uniform distribution with parameters:
Minimum 450.3 (=G36)
Maximum 502.1 (=U36)

Rollup APN COST - Cell: G5

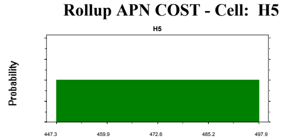


Mean value in simulation was 476.3

Assumption: H5

Uniform distribution with parameters:
Minimum 447.3 (=H36)
Maximum 497.9 (=V36)

Rollup APN COST - Cell: H5

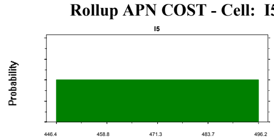


Mean value in simulation was 472.8

Assumption: I5

Uniform distribution with parameters:
Minimum 446.4 (=I36)
Maximum 496.2 (=W36)

Rollup APN COST - Cell: I5

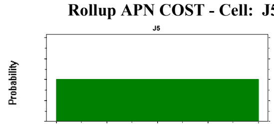


Mean value in simulation was 471.2

Assumption: J5

Uniform distribution with parameters:
Minimum 446.6 (=J36)
Maximum 496.0 (=X36)

Rollup APN COST - Cell: J5

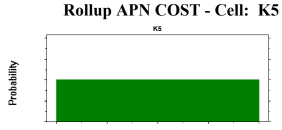


Mean value in simulation was 471.0

Assumption: K5

Uniform distribution with parameters:
Minimum 427.9 (=K36)
Maximum 474.5 (=Y36)

Rollup APN COST - Cell: K5

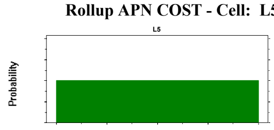


Mean value in simulation was 451.2

Assumption: L5

Uniform distribution with parameters:
Minimum 88.5 (=L36)
Maximum 98.5 (=Z36)

Rollup APN COST - Cell: L5

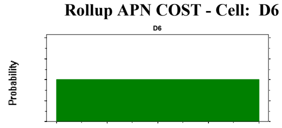


Mean value in simulation was 93.5

Assumption: D6

Uniform distribution with parameters:
Minimum 189.6 (=D45)
Maximum 198.5 (=R45)

Rollup APN COST - Cell: D6

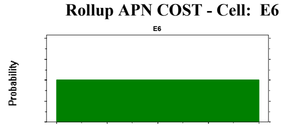


Mean value in simulation was 194.1

Assumption: E6

Uniform distribution with parameters:
Minimum 254.7 (=E45)
Maximum 270.0 (=S45)

Rollup APN COST - Cell: E6

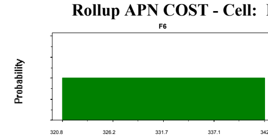


Mean value in simulation was 262.3

Assumption: F6

Uniform distribution with parameters:
Minimum 320.8 (=F45)
Maximum 342.6 (=T45)

Rollup APN COST - Cell: F6

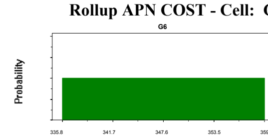


Mean value in simulation was 331.8

Assumption: G6

Uniform distribution with parameters:
Minimum 335.8 (=G45)
Maximum 359.4 (=U45)

Rollup APN COST - Cell: G6

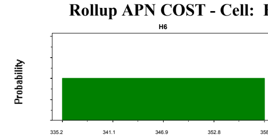


Mean value in simulation was 347.6

Assumption: H6

Uniform distribution with parameters:
Minimum 335.2 (=H45)
Maximum 358.7 (=V45)

Rollup APN COST - Cell: H6

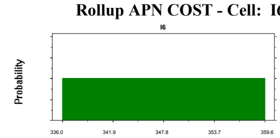


Mean value in simulation was 347.0

Assumption: I6

Uniform distribution with parameters:
Minimum 336.0 (=I45)
Maximum 359.6 (=W45)

Rollup APN COST - Cell: I6

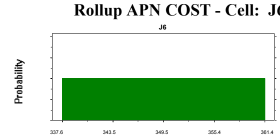


Mean value in simulation was 347.7

Assumption: J6

Uniform distribution with parameters:
Minimum 337.6 (=J45)
Maximum 361.4 (=X45)

Rollup APN COST - Cell: J6

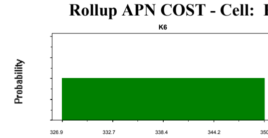


Mean value in simulation was 349.3

Assumption: K6

Uniform distribution with parameters:
Minimum 326.9 (=K45)
Maximum 350.0 (=Y45)

Rollup APN COST - Cell: K6

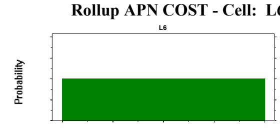


Mean value in simulation was 338.5

Assumption: L6

Uniform distribution with parameters:
Minimum 88.5 (=L45)
Maximum 98.5 (=Z45)

Rollup APN COST - Cell: L6

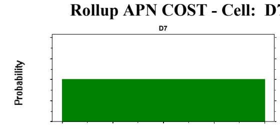


Mean value in simulation was 93.6

Assumption: D7

Uniform distribution with parameters:
Minimum 208.4 (=D55)
Maximum 230.6 (=R55)

Rollup APN COST - Cell: D7

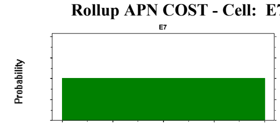


Mean value in simulation was 219.5

Assumption: E7

Uniform distribution with parameters:
Minimum 286.2 (=E55)
Maximum 323.9 (=S55)

Rollup APN COST - Cell: E7

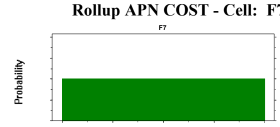


Mean value in simulation was 304.9

Assumption: F7

Uniform distribution with parameters:
Minimum 355.9 (=F55)
Maximum 402.8 (=T55)

Rollup APN COST - Cell: F7



Mean value in simulation was 379.6

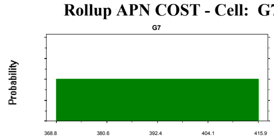
Assumption: G7

Uniform distribution with parameters:

Minimum	368.8	(=G55)
Maximum	415.9	(=U55)

Mean value in simulation was 392.0

Rollup APN COST - Cell: G7



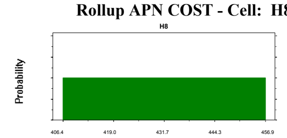
Assumption: H8

Uniform distribution with parameters:

Minimum	406.4	(=H66)
Maximum	456.9	(=V66)

Mean value in simulation was 431.9

Rollup APN COST - Cell: H8



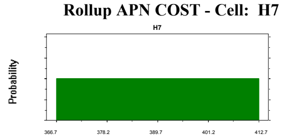
Assumption: H7

Uniform distribution with parameters:

Minimum	366.7	(=H55)
Maximum	412.7	(=V55)

Mean value in simulation was 389.9

Rollup APN COST - Cell: H7



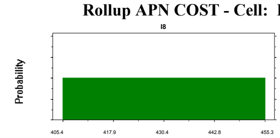
Assumption: I8

Uniform distribution with parameters:

Minimum	405.4	(=I66)
Maximum	455.3	(=W66)

Mean value in simulation was 429.8

Rollup APN COST - Cell: I8



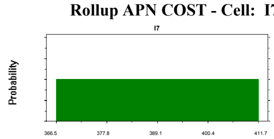
Assumption: I7

Uniform distribution with parameters:

Minimum	366.5	(=I55)
Maximum	411.7	(=W55)

Mean value in simulation was 389.0

Rollup APN COST - Cell: I7



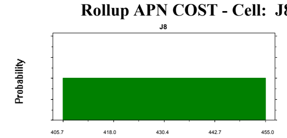
Assumption: J8

Uniform distribution with parameters:

Minimum	405.7	(=J66)
Maximum	455.0	(=X66)

Mean value in simulation was 430.3

Rollup APN COST - Cell: J8



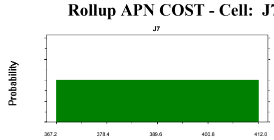
Assumption: J7

Uniform distribution with parameters:

Minimum	367.2	(=J55)
Maximum	412.0	(=X55)

Mean value in simulation was 389.5

Rollup APN COST - Cell: J7



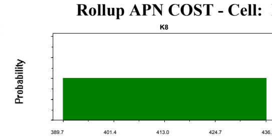
Assumption: K8

Uniform distribution with parameters:

Minimum	389.7	(=K66)
Maximum	436.3	(=Y66)

Mean value in simulation was 413.3

Rollup APN COST - Cell: K8



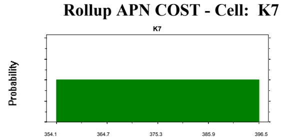
Assumption: K7

Uniform distribution with parameters:

Minimum	354.1	(=K55)
Maximum	396.5	(=Y55)

Mean value in simulation was 375.4

Rollup APN COST - Cell: K7



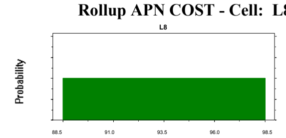
Assumption: L8

Uniform distribution with parameters:

Minimum	88.5	(=L66)
Maximum	98.5	(=Z66)

Mean value in simulation was 93.6

Rollup APN COST - Cell: L8



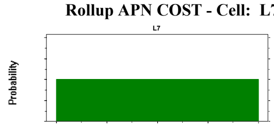
Assumption: L7

Uniform distribution with parameters:

Minimum	88.5	(=L55)
Maximum	98.5	(=Z55)

Mean value in simulation was 93.6

Rollup APN COST - Cell: L7



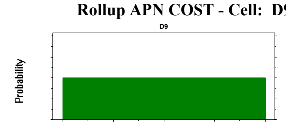
Assumption: D9

Uniform distribution with parameters:

Minimum	176.1	(=D75)
Maximum	198.3	(=R75)

Mean value in simulation was 187.2

Rollup APN COST - Cell: D9



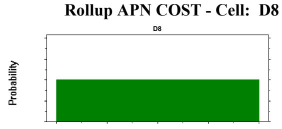
Assumption: D8

Uniform distribution with parameters:

Minimum	228.2	(=D66)
Maximum	252.8	(=R66)

Mean value in simulation was 240.5

Rollup APN COST - Cell: D8



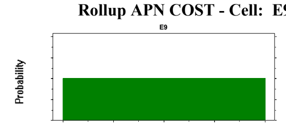
Assumption: E9

Uniform distribution with parameters:

Minimum	221.6	(=E75)
Maximum	259.3	(=S75)

Mean value in simulation was 240.6

Rollup APN COST - Cell: E9



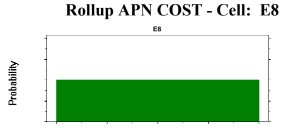
Assumption: E8

Uniform distribution with parameters:

Minimum	321.7	(=E66)
Maximum	363.6	(=S66)

Mean value in simulation was 342.6

Rollup APN COST - Cell: E8



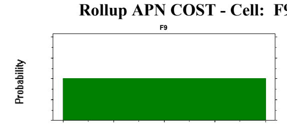
Assumption: F9

Uniform distribution with parameters:

Minimum	275.4	(=F75)
Maximum	322.2	(=T75)

Mean value in simulation was 298.9

Rollup APN COST - Cell: F9



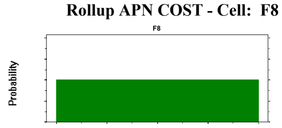
Assumption: F8

Uniform distribution with parameters:

Minimum	397.7	(=F66)
Maximum	449.4	(=T66)

Mean value in simulation was 423.9

Rollup APN COST - Cell: F8



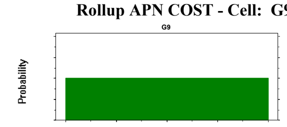
Assumption: G9

Uniform distribution with parameters:

Minimum	288.3	(=G75)
Maximum	335.3	(=U75)

Mean value in simulation was 312.1

Rollup APN COST - Cell: G9



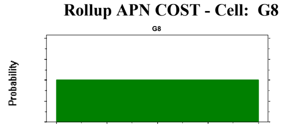
Assumption: G8

Uniform distribution with parameters:

Minimum	409.3	(=G66)
Maximum	461.1	(=U66)

Mean value in simulation was 435.2

Rollup APN COST - Cell: G8



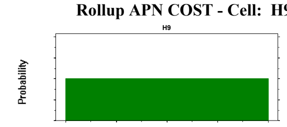
Assumption: H9

Uniform distribution with parameters:

Minimum	286.2	(=H75)
Maximum	332.2	(=V75)

Mean value in simulation was 309.3

Rollup APN COST - Cell: H9



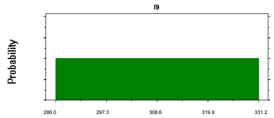
Assumption: I9

Uniform distribution with parameters:

Minimum	286.0	(=I75)
Maximum	331.2	(=W75)

Mean value in simulation was 308.5

Rollup APN COST - Cell: I9



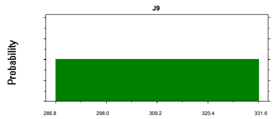
Assumption: J9

Uniform distribution with parameters:

Minimum	286.8	(=J75)
Maximum	331.6	(=X75)

Mean value in simulation was 309.1

Rollup APN COST - Cell: J9



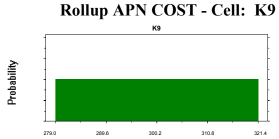
Assumption: K9

Uniform distribution with parameters:

Minimum	279.0	(=K75)
Maximum	321.4	(=Y75)

Mean value in simulation was 299.5

Rollup APN COST - Cell: K9



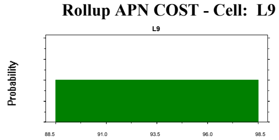
Assumption: L9

Uniform distribution with parameters:

Minimum	88.5	(=L75)
Maximum	98.5	(=Z75)

Mean value in simulation was 93.6

Rollup APN COST - Cell: L9



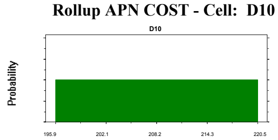
Assumption: D10

Uniform distribution with parameters:

Minimum	195.9	(=D85)
Maximum	220.5	(=R85)

Mean value in simulation was 208.2

Rollup APN COST - Cell: D10



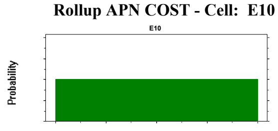
Assumption: E10

Uniform distribution with parameters:

Minimum	257.2	(=E85)
Maximum	299.0	(=S85)

Mean value in simulation was 277.9

Rollup APN COST - Cell: E10



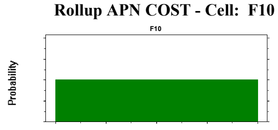
Assumption: F10

Uniform distribution with parameters:

Minimum	317.1	(=F85)
Maximum	368.8	(=T85)

Mean value in simulation was 342.7

Rollup APN COST - Cell: F10



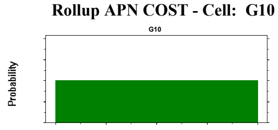
Assumption: G10

Uniform distribution with parameters:

Minimum	328.8	(=G85)
Maximum	380.6	(=U85)

Mean value in simulation was 354.5

Rollup APN COST - Cell: G10



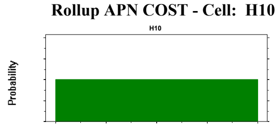
Assumption: H10

Uniform distribution with parameters:

Minimum	325.9	(=H85)
Maximum	376.4	(=V85)

Mean value in simulation was 351.2

Rollup APN COST - Cell: H10



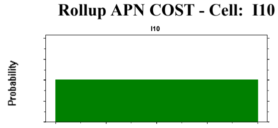
Assumption: I10

Uniform distribution with parameters:

Minimum	325.0	(=I85)
Maximum	374.8	(=W85)

Mean value in simulation was 350.2

Rollup APN COST - Cell: I10



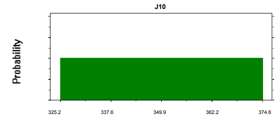
Assumption: J10

Uniform distribution with parameters:

Minimum	325.2	(=J85)
Maximum	374.6	(=X85)

Mean value in simulation was 349.7

Rollup APN COST - Cell: J10



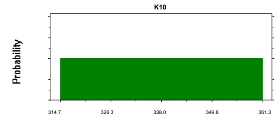
Assumption: K10

Uniform distribution with parameters:

Minimum	314.7	(=K85)
Maximum	361.3	(=Y85)

Mean value in simulation was 338.2

Rollup APN COST - Cell: K10



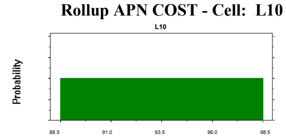
Assumption: L10

Uniform distribution with parameters:

Minimum	88.5	(=L85)
Maximum	98.5	(=Z85)

Mean value in simulation was 93.6

Rollup APN COST - Cell: L10



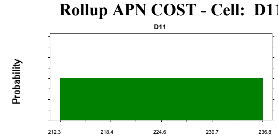
Assumption: D11

Uniform distribution with parameters:

Minimum	212.3	(=D96)
Maximum	236.8	(=R96)

Mean value in simulation was 224.6

Rollup APN COST - Cell: D11



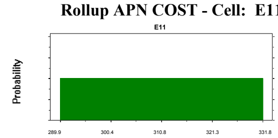
Assumption: E11

Uniform distribution with parameters:

Minimum	289.9	(=E96)
Maximum	331.8	(=S96)

Mean value in simulation was 311.0

Rollup APN COST - Cell: E11



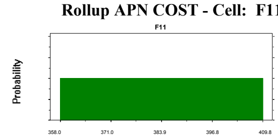
Assumption: F11

Uniform distribution with parameters:

Minimum	358.0	(=F96)
Maximum	409.8	(=T96)

Mean value in simulation was 383.8

Rollup APN COST - Cell: F11



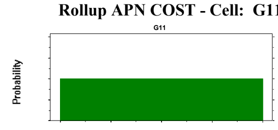
Assumption: G11

Uniform distribution with parameters:

Minimum	369.7	(=G96)
Maximum	421.5	(=U96)

Mean value in simulation was 395.6

Rollup APN COST - Cell: G11



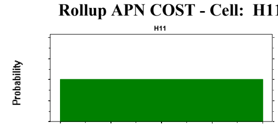
Assumption: H11

Uniform distribution with parameters:

Minimum	366.8	(=H96)
Maximum	417.4	(=V96)

Mean value in simulation was 391.4

Rollup APN COST - Cell: H11



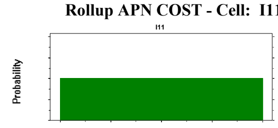
Assumption: I11

Uniform distribution with parameters:

Minimum	365.9	(=I96)
Maximum	415.7	(=W96)

Mean value in simulation was 390.6

Rollup APN COST - Cell: I11



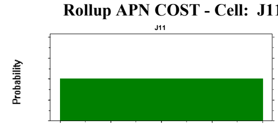
Assumption: J11

Uniform distribution with parameters:

Minimum	366.2	(=J96)
Maximum	415.5	(=X96)

Mean value in simulation was 390.8

Rollup APN COST - Cell: J11



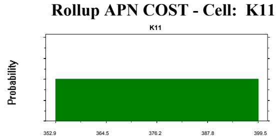
Assumption: K11

Uniform distribution with parameters:

Minimum	352.9	(=K96)
Maximum	399.5	(=Y96)

Mean value in simulation was 376.0

Rollup APN COST - Cell: K11



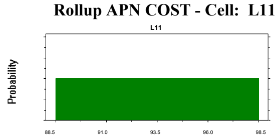
Assumption: L11

Uniform distribution with parameters:

Minimum	88.5	(=L96)
Maximum	98.5	(=Z96)

Mean value in simulation was 93.6

Rollup APN COST - Cell: L11



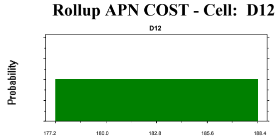
Assumption: D12

Uniform distribution with parameters:

Minimum	177.2	(=D105)
Maximum	188.4	(=R105)

Mean value in simulation was 182.9

Rollup APN COST - Cell: D12



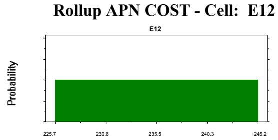
Assumption: E12

Uniform distribution with parameters:

Minimum	225.7	(=E105)
Maximum	245.2	(=S105)

Mean value in simulation was 235.6

Rollup APN COST - Cell: E12



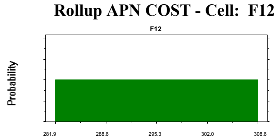
Assumption: F12

Uniform distribution with parameters:

Minimum	281.9	(=F105)
Maximum	308.6	(=T105)

Mean value in simulation was 295.3

Rollup APN COST - Cell: F12



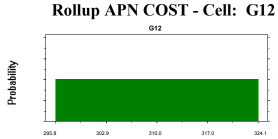
Assumption: G12

Uniform distribution with parameters:

Minimum	295.8	(=G105)
Maximum	324.1	(=U105)

Mean value in simulation was 309.9

Rollup APN COST - Cell: G12



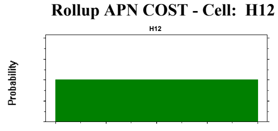
Assumption: H12

Uniform distribution with parameters:

Minimum	294.3	(=H105)
Maximum	322.5	(=V105)

Mean value in simulation was 308.3

Rollup APN COST - Cell: H12



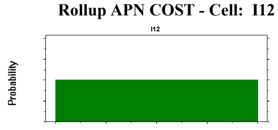
Assumption: I12

Uniform distribution with parameters:

Minimum	294.5	(=I105)
Maximum	322.6	(=W105)

Mean value in simulation was 308.5

Rollup APN COST - Cell: I12



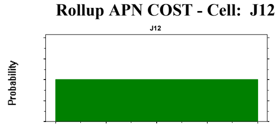
Assumption: J12

Uniform distribution with parameters:

Minimum	295.6	(=J105)
Maximum	323.9	(=X105)

Mean value in simulation was 309.7

Rollup APN COST - Cell: J12



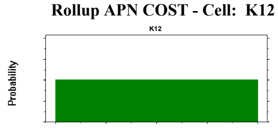
Assumption: K12

Uniform distribution with parameters:

Minimum	287.5	(=K105)
Maximum	314.8	(=Y105)

Mean value in simulation was 301.1

Rollup APN COST - Cell: K12



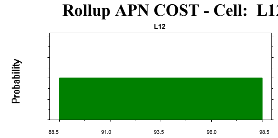
Assumption: L12

Uniform distribution with parameters:

Minimum	88.5	(=L105)
Maximum	98.5	(=Z105)

Mean value in simulation was 93.6

Rollup APN COST - Cell: L12



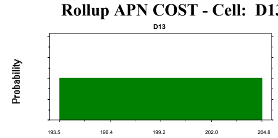
Assumption: D13

Uniform distribution with parameters:

Minimum	193.5	(=D115)
Maximum	204.8	(=R115)

Mean value in simulation was 199.1

Rollup APN COST - Cell: D13



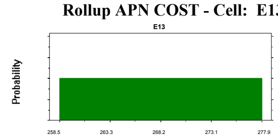
Assumption: E13

Uniform distribution with parameters:

Minimum	258.5	(=E115)
Maximum	277.9	(=S115)

Mean value in simulation was 268.2

Rollup APN COST - Cell: E13



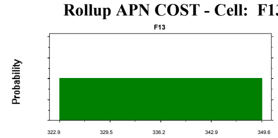
Assumption: F13

Uniform distribution with parameters:

Minimum	322.9	(=F115)
Maximum	349.6	(=T115)

Mean value in simulation was 336.1

Rollup APN COST - Cell: F13



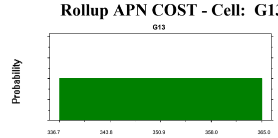
Assumption: G13

Uniform distribution with parameters:

Minimum	336.7	(=G115)
Maximum	365.0	(=U115)

Mean value in simulation was 350.7

Rollup APN COST - Cell: G13



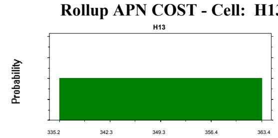
Assumption: H13

Uniform distribution with parameters:

Minimum	335.2	(=H115)
Maximum	363.4	(=V115)

Mean value in simulation was 349.3

Rollup APN COST - Cell: H13



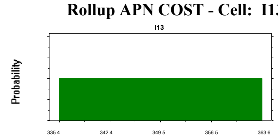
Assumption: I13

Uniform distribution with parameters:

Minimum	335.4	(=I115)
Maximum	363.6	(=W115)

Mean value in simulation was 349.4

Rollup APN COST - Cell: I13



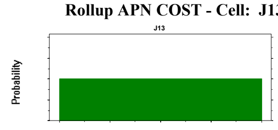
Assumption: J13

Uniform distribution with parameters:

Minimum	336.5	(=J115)
Maximum	364.8	(=X115)

Mean value in simulation was 350.8

Rollup APN COST - Cell: J13



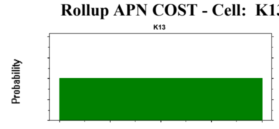
Assumption: K13

Uniform distribution with parameters:

Minimum	325.7	(=K115)
Maximum	353.0	(=Y115)

Mean value in simulation was 339.6

Rollup APN COST - Cell: K13



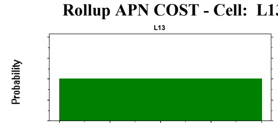
Assumption: L13

Uniform distribution with parameters:

Minimum	88.5	(=L115)
Maximum	98.5	(=Z115)

Mean value in simulation was 93.5

Rollup APN COST - Cell: L13



APPENDIX D. LMDSS R/S/C MATRIX SAMPLE OUTPUT

AHXD/CH-53E
October 1999 to September 2000
Flight Hours: 20766 Aircraft Reporting: 81% Sorted by: Support$
Service: Marine Command: Atlantic Pacific Reserves Training Marine WUC Range: All
Row Format: Actual Values

WUC	Nomenclature	Support$	AFM$	AVDLR$	DMMH$
15	ROTARY WINGS	30864315	1705060	23224463	5934792
26	VTOL/STOL TRANSMISSIONS/DRIVES	17926591	1448875	13485819	2991897
3	MAINTENANCE INSPECTIONS	15855044	44450	0	15810594
22	TURBOSHAFT ENGINES	10787812	1559626	6801993	2426193
11	AIRFRAME	10045964	2809088	312148	6924728
29	POWER PLANT INSTALLATION	9503904	1660201	2093104	5750599
42	ELEC PWR SUPPLY/DISTR/LIGHTING SYS	9056204	6034952	357651	2663601
14	DIRECTIONAL FLT CONTROL/LIFT SYSTEMS	5251822	936984	2350690	1964148
13	ALIGHTING/LAUNCHING SYSTEM	4471833	772393	1315447	2383993
46	FUEL SYSTEM	4306023	525096	1809960	1970967
12	FURNISHINGS/COMPARTMENTS	3531831	1918263	947293	666275
45	HYDRAULIC SYSTEMS	3207817	790117	907326	1510374
4	CORROSION PREVENTION	2896956	1828	0	2895128
49	MISC EMERGENCY/UTILITY SYSTEMS	2728859	1207879	861556	659424
24	AUXILIARY POWER PLANT (AIRBORNE)	2573267	529526	1557638	486103
57	INTEGRATED GUIDANCE/FLT CONT SYSTEMS	1599891	253196	442371	904324
56	FLIGHT REFERENCE SYSTEMS	1419039	17071	1080601	321367
71	RADIO NAVIGATION SYSTEMS	1023271	159501	385259	478511
91	EMERGENCY EQUIPMENT	927181	826698	0	100483
64	INTERPHONE SYSTEMS	907855	305554	982	601319
51	INSTRUMENTATION SYSTEMS	670503	81586	242948	345969
76	COUNTERMEASURES SYSTEMS	606231	100396	80095	425740
72	RADAR NAVIGATION SYSTEMS	562018	165730	71756	324532
41	ENVIRONMENTAL CONTROL/PNEU SYSTEMS	522507	189012	73840	259655
62	VHF COMMUNICATIONS SYSTEMS	430196	16510	114849	298837
97	EXPLOSIVE DEVICES	329021	4878	0	324143
44	LIGHTING SYSTEMS	327204	312991	191	14022
48	ICE/RAIN REMOVAL/PROTECTION SYSTEMS	297598	178478	11980	107140
65	IFF SYSTEMS	296836	29320	34507	233009
61	HF COMMUNICATIONS SYSTEMS	156844	28328	13775	114741
75	WEAPON DELIVERY	99028	71322	0	27706
73	BOMBING NAVIGATION SYSTEMS	51833	1602	36784	13447
63	UHF COMMUNICATIONS	42997	15645	0	27352
67	COM/NAV/IFF INTEGRATED PACKAGE SYSTE	30890	227	4570	26093
16	[WUC NOMENCLATURE NOT FOUND]	30709	28063	632	2014
5	GENERAL AERONAUTICAL FUNCTIONS	14218	2	0	14216
96	PERSONNEL EQUIPMENT	7646	735	0	6911
66	EMERGENCY RADIO SYSTEMS	7479	3321	0	4158
69	MISCELLANEOUS COMMUNICATIONS SYSTEMS	7463	237	0	7226
78	[WUC NOMENCLATURE NOT FOUND]	5831	5831	0	0
10	[WUC NOMENCLATURE NOT FOUND]	3676	80	0	3596
74	WEAPONS CONTROL SYSTEMS	3430	0	3430	0
93	DECELERATION/DRAG CHUTE SYSTEMS	2543	375	0	2168
32	HYDRAULIC PROPELLERS	2132	0	0	2132
77	PHOTOGRAPHIC/RECONNAISSANCE SYSTEMS	2118	0	0	2118
9	NONAERONAUTICAL WORK	2029	558	0	1471
19	[WUC NOMENCLATURE NOT FOUND]	711	0	0	711
23	TURBOJET ENGINES	594	594	0	0
27	TURBOFAN ENGINES	447	447	0	0
52	AUTOPILOT SYSTEMS	426	0	0	426
36	[WUC NOMENCLATURE NOT FOUND]	299	299	0	0
89	[WUC NOMENCLATURE NOT FOUND]	287	3	0	284
59	TARGET SCORING AND AUGMENTATION SYSTE	284	0	0	284
39	[WUC NOMENCLATURE NOT FOUND]	256	0	0	256
58	IN-FLIGHT TEST EQUIPMENT SYSTEMS	253	182	0	71
31	[WUC NOMENCLATURE NOT FOUND]	213	0	0	213
87	[WUC NOMENCLATURE NOT FOUND]	213	0	0	213
54	TELEMETRY SYSTEMS	100	0	0	100
25	[WUC NOMENCLATURE NOT FOUND]	93	1	0	92
53	DRONE GUIDANCE SYSTEMS	71	0	0	71
28	[WUC NOMENCLATURE NOT FOUND]	50	0	0	50
47	OXYGEN SYSTEMS	50	0	0	50
17	ESCAPE SYSTEMS	43	43	0	0
81	AIRBORNE GUIDED WEAPONS	36	0	0	36
8	INSPECTION OF SAFETY/SURVIVAL EQUIPMENT	0	0	0	0
20	[WUC NOMENCLATURE NOT FOUND]	0	0	0	0
34	ROTARY WING SYSTEM	0	0	0	0

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APPENDIX E. OPERATION EFFECTIVENESS SURVEY

CH-53E MODERNIZATION SURVEY

This survey will be used as a tool to evaluate the performance of proposed modernization configurations for the CH-53E helicopter. The questions posed are not meant to be all encompassing and are only part of the cost effectiveness analysis being conducted.

For the purposes of this study only six modernization elements are being considered. Those elements combine to create ten feasible, while not necessarily desirable, configurations. Each of the ten configurations is then evaluated or scored against how well the evaluator believes that configuration would be able to perform a given Mission Essential Task List (METL) for the CH-53E. Evaluators should consider in their evaluation how well a particular modernization configuration would perform a METL in the 2010-2025 timeframe, as this is when a modernized CH-53E would be in service. Lastly, evaluators will be asked to provide an ordered percentage weighting of the METLs such that they total to equal 100%.

It is important that evaluators have a clear understanding of the information the survey seeks. Specifically, my cost effectiveness analysis assumes a couple of key facts: 1) That the CH-53E must remain in service until approximately 2025 in order to satisfy the Marine Corps' heavy lift requirement. 2) Because of (1), a SLEP is mandatory and therefore the only remaining question is what other upgrades/modernization is required in order to ensure that the CH-53E remains a viable and capable platform until a replacement system can be fielded. This is one of the questions my thesis seeks to answer. While the adjectival descriptors used in the evaluation are somewhat vague, this is done intentionally in order to allow evaluators the latitude to interpret how the modernization configurations might improve performance. Additionally, I felt that because the details of some of the modernization elements are yet to be fully defined (i.e. the improved hook system and the cockpit), it would be difficult to strictly quantify performance improvements.

The evaluation being performed should focus on how each of the modernization configurations improves the aircraft's performance in a given METL profile. Improved performance here is defined broadly as: **Anything that makes the aircraft more effective and/or efficient in performing its given mission on the battlefield.** Evaluators should take this to include such items as safety and human systems integration improvements that reduce pilot/crew workload and enhance mission situational awareness. Additionally, while the cost benefits of maintenance improvements will be captured in the "cost" side of the analysis, evaluators should take into account the increased effectiveness of the CH-53E arising from higher mission capable rates due to modernization enhancements. A separate payload and range measure will also be incorporated independent of these evaluations as another measure of performance. Other elements of analysis such as reduced O&S costs will be captured in other portions of the study. It is understood that these evaluations are subjective and qualitative vice quantitative, this is done intentionally in order to capture an "expert opinion" on how the given modernization configurations will affect mission performance.

Below, are a listing and description of the modernization elements, possible configurations, the METLs each to be ranked and the possible adjectival "scores" with "definitions" in ranked order.

Modernization Elements:

1. Service Life Extension (S): Consists of structural reinforcement and replacement of fatigued areas. Required in order to provide capability until 2025.
2. New Engines (E): Consists of replacing existing engines with more powerful engines currently being used on the KC-130J and MV-22 thus providing operating improvements and maintenance (O&M) cost savings.
3. Improved Main Rotor Blade (B): All composite material design that provides additional lift and performance capability due to delayed onset of blade stall.
4. Elastomeric Rotor Head (R): Replaces current "wet head" design with elastomeric bearings resulting in simpler and less frequent maintenance.
5. Improved External Cargo Hook System (H): Replaces current system and takes advantage of the increased capabilities created by new blades and engines.
6. Common Cockpit (C): Unsure as to exact nature but will include improved communication and navigation suite that is interoperable with current C^4I systems fielded in other platforms as well as improved pilot visibility.

Modernization Configurations:

Modernization Configuration Options (Combinations use abbreviations indicated above)	
1	S (SLEP ONLY)
2	S,E,B,R,H & C (ALL SIX)
3	S,E,H
4	S,E,B,H
5	S,E,B,R,H
6	S,B
7	S,B,R
8	S,B,R,C
9	S,R
10	S,R,C

Mission Essential Task List:

Abbr.	**METL Description**
Assault	Provide assault transport of combat troops, equipment, and supplies.
Raids	Provide assault support for conduct of amphibious raids.
TRAP	Conduct tactical retrieval and recovery operations for downed aircraft, equipment and personnel.
MEDEVAC	Provide support for MEDEVAC operations.
SPECOps	Conduct assault support for maritime special operations.
NEO	Conduct assault support for evacuation operations.
ShipOps	Maintain capability to operate from amphibious shipping, floating bases, and forward operating bases.
Night/IMC	Operate at night, in adverse weather, and under instrument flight conditions at extended ranges.

Adjectival Evaluation Scores:

A. Significantly enhances current capability

Performance improvement is likely to meet projected requirements until 2025.

B. Enhances current capability

Performance will be improved but will likely require further improvements/technology refreshment before system retirement.

C. Doesn't alter current capability

Self-explanatory.

D. Provides for Limited capability

System will still meet some requirements but will be unable to meet the full range of projected requirements until 2025.

E. Lack of capability is a performance liability

Performance shortfall will likely result in the inability of the Marine Corps to successfully prosecute the sort of missions anticipated until 2025.

Performance Assessment

	Assault	Raid	TRAP	MEDEVAC	SPEC Ops	NEO	Ship Ops	Night/IMC	
S (SLEP ONLY)									
S,E,B,R,H & C (ALL SIX)									
S,E,H									
S,E,B,H									
S,E,B,R,H									
S,B									
S,B,R									
S,B,R,C									
S,R									
S,R,C									
Weights									

Please use the letters below to enter your score.

A. Significantly enhances current capability

B. Enhances current capability

C. Doesn’t alter current capability

D. Provides for Limited capability

E. Lack of capability is a performance liability

Total of weights across METLs must sum to equal 100. Tenths of a point can be used if the evaluator believes it to be necessary.

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